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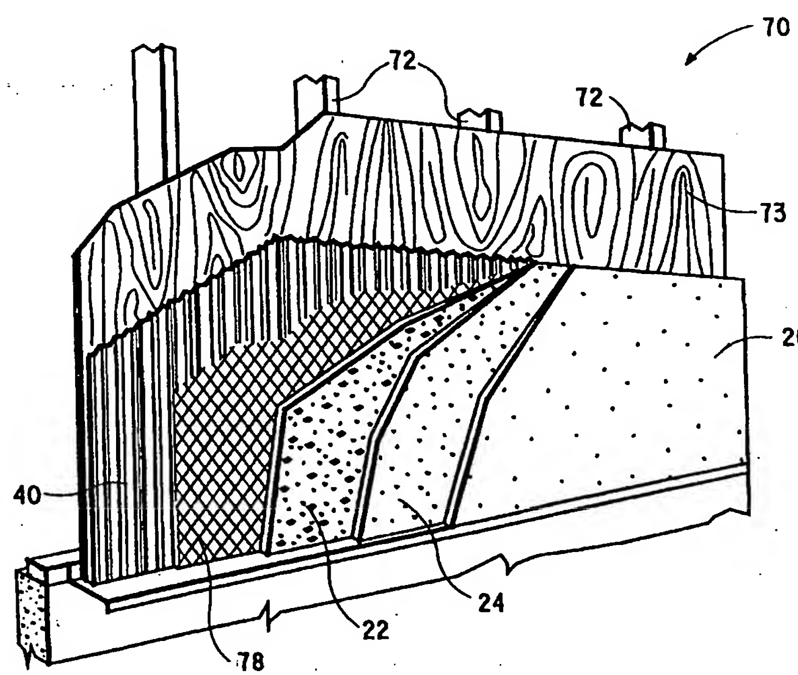
(57) Abstract

A construction membrane that resists liquid and air penetration, is moisture vapor permeable, and has integral drainage channels is provided. An exterior wall construction incorporating such barrier sheet material is also provided. The wall construction may be faced with stucco, siding, brick or stone. A method for removing moisture from an exterior wall construction is also provided.



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TITLE
CONSTRUCTION MEMBRANE

Field of the Invention

This invention relates to air and water infiltration barrier sheet materials useful in the construction of housing and other structures. More particularly, the invention relates to a sheet material that is permeable to moisture vapor, but is substantially impermeable to liquids and air, and that provides channels for drainage of liquids when the sheet material is incorporated in a wall construction. The invention further relates to wall constructions made with such sheet material, including stucco-faced wall constructions, brick-faced and stone-faced wall constructions, and wood and vinyl siding wall constructions.

Background of the Invention

A number of different air and/or water infiltration barrier materials are currently used in the construction of the external walls of structures. Barrier materials are available in the form of sheets that can be incorporated into the walls of a structure under the outer facade of the wall. Such barrier sheet materials are designed to prevent the intrusion of incidental water, which passes through the primary facade, into the frame of the structure where water could cause mold, mildew, rotting, or other structural damage. Some barrier sheet materials also prevent the infiltration of air (and the moisture carried with such air) into the structure so as to make the structure more comfortable and energy efficient. While barrier sheet materials should be substantially impermeable to liquid water and air, they should not trap moisture vapor within walls where the vapor could condense as water and cause mildew or structural damage. It is also important that a barrier sheet material not trap water that enters walls through exterior cracks, around windows, doors and other joints, or around water taps or electric fixtures.

Barrier sheet material has been used in most kinds of exterior wall constructions including wall constructions with stucco, brick, stone, and siding facades. Barrier sheet materials used under siding include asphalt impregnated kraft papers and felts, perforated polymer films, spunbonded polymer sheets, and microporous film laminates. Barrier sheet materials that have been used under

stucco include asphalt impregnated kraft papers and felts, spunbonded polymer sheets, and perforated polymer films.

One barrier sheet material that has been advantageously used in both siding and stucco wall constructions is TYVEK® spunbonded polyethylene sheet sold by E.I. duPont de Nemours & Company of Wilmington, Delaware ("DuPont"). Tyvek® is a registered trademark of DuPont. TYVEK® spunbonded polyethylene sheet is made from a consolidated web of flash-spun polyethylene plexifilamentary film-fibrils made as disclosed in U.S. Patent No. 3,169,899 to Steuber and bonded as disclosed in U.S. Patent No. 3,532,589 to David or PCT Publication No. WO 97/40224 (all assigned to DuPont). As used herein, the term "plexifilamentary" means a three-dimensional integral network of a multitude of thin, ribbon-like, film-fibril elements of random length and with a mean film thickness of less than about 10 microns and a median fibril width of less than about 25 microns. In plexifilamentary structures, the film-fibril elements are generally coextensively aligned with the longitudinal axis of the plexifilamentary structure and they intermittently unite and separate at irregular intervals in various places throughout the length, width and thickness of the plexifilamentary structure to form a continuous three-dimensional network. A TYVEK® spunbonded polyethylene sheet designed for use as a barrier sheet material for construction applications has been sold by DuPont under the names TYVEK® Housewrap and TYVEK® HOMEWRAP™.

In structures made using frame construction, the frame of the structure is generally made from metal or wood studs covered with an exterior sheathing such as plywood, oriented strand board ("OSB"), composite particle board, gypsum board, or foam sheeting. This exterior sheathing is covered with a barrier sheet material, which is then covered with an exterior facade material such as wood siding, hardboard or vinyl siding, brick or stone, or stucco. In some cases, the barrier sheet material is applied directly to the frame studs without an exterior sheathing ("open frame construction").

Siding is generally applied directly over the barrier sheet material by pounding nails through the siding, the barrier sheet material, and into the sheathing or the studs. The nail holes through the barrier sheet material can provide an avenue through which air, moisture vapor, or water can get through the barrier sheet material. Water incursion behind barrier sheet material applied under siding can also occur around windows, doors, and electrical fixtures that have been poorly flashed or caulked, or at other joints and penetrations. If water finds its way behind the barrier sheet material, whether through nail holes or through

poorly sealed joints, this bulk water can build up behind the barrier sheet where the water is likely to damage to the structure's sheathing, insulation or frame.

Where a barrier sheet material is used in frame construction faced with brick or stone, water can find its way into walls through cracks and pores in the pointing, the brick, or the stone. Water incursion through the brick or stone facade is most likely to occur around windows, doors, and electrical fixtures, and along the roof line, especially if joints have been improperly flashed or caulked. Water that penetrates the exterior facade can then penetrate the barrier sheet material if it is difficult for the water to drain down the exterior side of the barrier sheet. Water that finds its way behind barrier sheet material applied under brick or stone may damage to the structure's sheathing, insulation or frame.

In frame construction faced with traditional three coat Portland cement plaster, known as stucco, the barrier sheet material is incorporated into the stucco-faced wall construction 10, as shown in Figure 1. In the stucco-faced wall construction 10, the studs 12 of the structure are covered with either line wires 14 (open frame construction) or with one of the sheathing materials (not shown) discussed above. The wires 14 or the sheathing are covered with a barrier sheet 16. In stucco-faced wall constructions, the barrier sheet materials that have traditionally been used are asphalt impregnated rag felts and water resistant papers such as asphalt saturated kraft paper. Another barrier sheet that has more recently been used in stucco-faced frame construction is TYVEK® spunbonded polyethylene sheet. The barrier sheet material can be stapled, nailed or glued to the studs or sheathing material. A metal lath 18, such as a self-furred hexagonal woven wire lath ("chicken wire"), is applied over the barrier sheet 16 and attached to the studs 12 and/or the sheathing with staples or furring nails (not shown). A scratch coat 22 of stucco is applied over the wire lath 18 so that the stucco passes through the lath and contacts the barrier sheet. After the scratch coat has had an opportunity to dry, an intermediate brown coat 24 of stucco is applied over the scratch coat 22. Once the brown coat has had an opportunity to dry, a finish coat 26 of stucco is applied over the brown coat 24. Finish coat 26 may be pigmented or the finish coat may be painted.

Cracking of stucco frequently occurs while the stucco is drying and curing, or during subsequent thermal expansion and contraction of the sheathing, wood studs, or stucco. Water can pass through cracks in the stucco, through improperly sealed joints, or even through the porous stucco itself. Water that finds its way between the stucco and the barrier sheet, and water absorbed into an absorbent barrier sheet material (such as kraft paper), can generate additional breakdown of the stucco. Water passing through an absorbent barrier material can

wet wooden studs so as to cause crack inducing expansion and contraction of the wall. Water absorbed into the barrier material and water present on the front or back sides of the barrier material may also generate rot in the barrier material, generate mildew and mold problems, and generate cracks in the stucco during freeze/thaw cycles. Water and moisture in the wall may also damage a structure's sheathing, insulation, or frame.

Water and moisture can also be a problem in synthetic stucco-faced wall constructions made using hybrid systems or Exterior Insulation and Finish Systems ("EIFS"). In a hybrid system and in some EIFS systems, a barrier sheet is applied either directly over the studs of a structure or over sheathing applied over the studs. In hybrid systems and in some EIFS systems that use a barrier sheet, an insulating foam board is applied over the barrier sheet and one or more coats of stucco are applied over the foam board. The foam may be screwed, nailed or otherwise fastened over the barrier sheet. In EIFS systems that do not use a barrier sheet, the foam board is glued or nailed directly to the exterior sheathing. The stucco coating is sometimes applied to the foam board prior to installation on a structure. Moisture intrusion behind the foam board has been a problem with EIFS systems, especially where no barrier sheet is used or where paper or felt are used as the barrier sheet material. Moisture trapped behind the foam can cause rot, mold and mildew problems in the wall.

Attempts have been made to facilitate the removal of water and water vapor from walls into which a barrier sheet is incorporated by building a cavity or channels next to the barrier sheet to provide an avenue through which water and water vapor can get out of the wall. For example, EIFS constructions have been made in which thin strips or a porous mat are inserted between the barrier sheet and the foam board in order to create channels through which water can escape the wall. In another EIFS construction, channels have been cut into the surface of the foam board that faces the barrier sheet to provide an avenue for the escape of water. The creation of cavities or channels next to the barrier sheet generally requires an expenditure of labor and or materials that make wall constructions with such channels unduly expensive to produce.

Accordingly, in exterior wall constructions where a barrier sheet material is used, there is a need for a barrier sheet material that facilitates the removal of bulk water and water vapor from the wall. Such a barrier sheet material should be substantially impermeable to air and liquid water, but it should not be impermeable to water vapor. The barrier sheet material should not readily absorb water or water vapor that can cause damage in a wall and the barrier sheet should not be made of a material that might rot. For stucco applications, it is also

preferred that the barrier sheet material not hinder the stucco curing process. It is also believed that for stucco-faced wall constructions, the barrier sheet is preferably made of a material to which stucco readily bonds.

Summary of the Invention

The invention provides a construction membrane comprising a barrier sheet material having a basis weight of less than 600 g/m^2, a hydrostatic head of greater than 12 cm, a Gurley Hill porosity of greater than 10 seconds, a moisture vapor transmission rate, measured by the LYSSY method, of at least 25 $g/m^2/day$, and integral channel means oriented in at least one general direction for providing a path by which a liquid against the sheet can drain. The preferred barrier sheet material is a unitary sheet. The integral channel means may comprises grooves formed on at least one side of the barrier sheet material. Preferably, the barrier sheet material has a basis weight of less than 300 g/m^2, a hydrostatic head of greater than 50 cm, a Gurley Hill porosity of greater than 60 seconds, and a moisture vapor transmission rate, measured by the LYSSY method, of at least 100 $g/m^2/day$. More preferably, the barrier sheet material has a basis weight of less than 125 g/m^2, a hydrostatic head of greater than 150 cm, a Gurley Hill porosity of greater than 120 seconds, and a moisture vapor transmission rate, measured by the LYSSY method, of at least 250 $g/m^2/day$. Most preferably, the barrier sheet material has a basis weight of less than 125 g/m^2, a hydrostatic head of greater than 150 cm, a Gurley Hill porosity of greater than 120 seconds, and a moisture vapor transmission rate, measured by the LYSSY method, of at least 250 $g/m^2/day$.

According to a preferred embodiment of the invention, the barrier sheet material is a fibrous sheet. The fibrous sheet is preferably a nonwoven sheet of synthetic fibers. The nonwoven sheet may be a spunbonded sheet comprised of polyolefin polymer fibers. Preferably, the spunbonded sheet consists essentially of polyethylene plexifilamentary film fibrils.

According to the preferred embodiment of the invention, the integral channel means are formed in said barrier sheet material by a process selected from the group of creping, embossing and microstretching. Preferably the channel means comprise a pattern of longitudinally extending substantially contiguous waves, said waves having an amplitude of at least 200 microns and a wave length of at least 1 mm. The integral channel means may comprises grooves formed on at least one side of the barrier sheet material. In an embossed barrier sheet material, the sheet should be embossed with a pattern of raised portions that are spaced from each other and extend at least 100 microns out from the first surface

of said barrier sheet material. According to an alternative embodiment of the invention, the integral channel may comprise spacing means attached to at least one side of the barrier sheet material, wherein the spacing means have a thickness of at least 200 microns and are selected from the group of synthetic scrim materials, plastic line, coarse nonwovens, and adhesive lumps.

The preferred barrier sheet has a drainage rate, measured according to the Barrier Sheet Drainage Test Method, of at least 150 ml/hr/inch, and more preferably of at least 1000 ml/hr/inch, and most preferably of at least 2000 ml/hr/inch.

The present invention is also directed to a wall structure comprising a support frame, a barrier sheet material over said support frame, and an exterior protective layer over said barrier sheet in which the barrier sheet material has a basis weight of less than 600 g/m^2, a hydrostatic head of greater than 12 cm, a Gurley Hill porosity of greater than 10 seconds, a moisture vapor transmission rate, measured by the LYSSY method, of at least 25 g/m^2/day, and integral channel means oriented in a generally vertical direction for providing a path by which a liquid against the sheet can drain. The exterior protective layer may be selected from the group of stucco, hybrid stucco, brick, stone, wood siding, metal siding, and synthetic siding materials. Preferably, the barrier sheet material is a unitary sheet. It is also preferred that the barrier sheet material have a basis weight of less than 300 g/m^2, a hydrostatic head of greater than 50 cm, a Gurley Hill porosity of greater than 60 seconds, and a moisture vapor transmission rate, measured by the LYSSY method, of at least 100 g/m^2/day.

The invention is also directed to a method for removing moisture from an exterior wall of a structure, comprising the steps of constructing a support frame; covering said support frame with a barrier sheet material, said barrier sheet material having a basis weight of less than 600 g/m^2, a hydrostatic head of greater than 12 cm, a Gurley Hill porosity of greater than 10 seconds, a moisture vapor transmission rate, measured by the LYSSY method, of at least 25 g/m^2/day, and integral channel means oriented in a generally vertical direction for providing a path by which a liquid against the sheet can drain; and covering the barrier sheet material with an exterior protective layer.

Brief Description of the Drawings

The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate the presently preferred embodiments of the invention and, together with the description, serve to explain the principles of the invention.

Figure 1 is a cut away view of an open frame stucco-faced wall construction according to the prior art.

Figure 2 is a perspective view of a barrier sheet material made according to one embodiment of the invention.

Figure 3 is a perspective view of a barrier sheet material made according to another embodiment of the invention.

Figure 4 is a cross-sectional view of a creping apparatus that can be used to make the barrier sheet material of the invention.

Figure 5 is an end view of the of a barrier sheet material made according to the invention.

Figure 6 is a cut away view of a stucco-faced wall construction over wood sheathing board made according to the present invention.

Figure 7 is a cut away view of an EIFS or hybrid wall construction made according to the present invention.

Figure 8 is a front view of a wall section frame to which a barrier sheet material can be attached.

Figure 9 is a front view of another wall section frame to which a barrier sheet material can be attached.

Figure 10 is a perspective view of a drainage testing unit used for testing the drainage properties of barrier sheet materials.

Detailed Description of the Invention

Reference will now be made in detail to the presently preferred embodiments of the invention, examples of which are illustrated below.

According to the present invention, a sheet material is provided that acts as a barrier to the infiltration of most air and liquid water, but does not act as a barrier to the passage of moisture vapor. The sheet material includes integral channel means for providing a passage through which water can flow out of a wall into which the sheet material is incorporated as a barrier sheet. Preferably the channel means are elongated grooves formed on at least one surface of the sheet. Such elongated grooves may be formed by embossing, creping, or otherwise texturing a flat sheet.

The barrier sheet material of the invention is preferably flexible and preferably has a basis weight of less than 340 g/m^2 (10 oz/yd^2), and more preferably less than about 136 g/m^2 (4 oz/yd^2). The barrier sheet material of the invention should act as a barrier to the passage of water (i.e., has a hydrostatic head of greater than 12 cm, and more preferably greater than about 75 cm, and most preferably greater than about 180 cm.) The barrier sheet material of the

invention also preferably acts as an air infiltration barrier (i.e., has a Gurley Hill Porosity of greater than 10 seconds (air permeability decreases with increasing Gurley Hill Porosity values), and more preferably greater than about 100 seconds, and most preferably greater than 250 seconds. The barrier sheet material of the invention should not block the transmission of moisture vapor (i.e., has a moisture vapor transmission rate, measured by the LYSSY method, of at least 35 $g/m^2/day$, and more preferably at least 200 $g/m^2/day$, and most preferably at least 800 $g/m^2/day$.

According to the present invention, the barrier sheet material includes integral channel means oriented in at least one general direction for providing a path of escape for water trapped in a wall into which the barrier sheet is incorporated. As used herein, "integral channel means" is defined to mean channels that are incorporated into the barrier sheet material and do not require a separate structure or layer apart from the barrier sheet material. Preferably, the barrier sheet material is a unitary sheet. As used herein, "unitary sheet" means a sheet with a substantially homogeneous composition that is free of laminations or other support structures.

Preferably, the channel means are comprised of grooves formed on at least one side of the sheet material. It is further preferred that the grooves be oriented generally in either the machine direction or the cross direction of the sheet material in order to facilitate the application of the barrier sheet to a wall construction in a manner that the grooves are oriented in a generally vertical direction whereby water in the grooves of the barrier sheet will be drained down through the grooves by gravitational forces. As used herein, the machine direction is the long direction within the plane of the sheet, i.e., the direction in which the sheet is produced. The cross direction is the direction within the plane of the sheet that is perpendicular to the machine direction. More preferably, the grooves are oriented in the cross direction of the sheet material such that a roll of the material can be used to horizontally wrap the length of a single story wall section with the grooves oriented in a generally downwardly direction. In other situations were structures are wrapped vertically, it will be more desirable that the grooves run in the sheet's machine direction.

The grooves of the barrier sheet are preferably between 0.2 and 1 mm deep and between 2.5 and 10 mm wide. In the presently preferred embodiment of the invention shown in Figure 2, the grooves are substantially straight and parallel with each other. However, it is anticipated that the grooves could be arranged in other generally vertical patterns such as the diamond pattern on the sheet 41 (shown in Figure 3) or a vertical wave pattern. The grooves can be made by

known methods for texturing a bonded sheet, as for example by embossing, creping or micro-stretching. It is preferred that the channels or grooves be arranged such that the space between grooves be no more than ten times the width of the grooves. In the preferred embodiment of the invention shown in Figure 2, the grooves are about 6.4 mm wide such that there are 4 to 5 grooves per 2.5 cm.

According to an alternative embodiment of the invention, the channel means may be comprised of a pattern of raised areas or raised portions on the sheet. One such pattern is a pattern of raised buttons embossed into the sheet. When such a sheet is incorporated into a wall, the areas of the sheet between the raised areas form the channel means. One advantage of a sheet in which the channel means are formed by a pattern of raised areas is that upon installation, the sheet will have substantially vertical channels, regardless of the direction in which the sheet material is installed on a structure. According to another embodiment of the invention, the integral channel means may be provided by laminating a netting, a scrim, a monofilament plastic line (fishing line), or a coarse nonwoven of high permeability directly to one or both sides of the barrier sheet. Alternatively, integral channel means may be provided by applying a random or regular array of individual spacers to one or both sides of the sheet material. The spacers may, for example, comprises small blobs or dots of a polymeric hot melt adhesive deposited on the sheet. Preferably, the spacers extend at least 200 microns above the surface of the sheet material to which they are applied, and more preferably at least 500 microns above the surface. Preferably, the spacers have a width of less than about 10 cm, and they are spaced between about 0.3 cm and 20 cm from each other.

Flat sheets that can be used in making the barrier sheet material of the invention include sheets of spunbonded synthetic fibers such as polyethylene, polypropylene or polyester fibers, sheets of spunbonded/meltblown/spunbonded ("SMS") polymer fibers, perforated polymer films, microporous film laminates, and building papers. Preferably, the barrier sheet material of the invention is made of a material that does not rot or readily lose its strength when subjected the temperature and humidity conditions commonly experienced within the walls of structures over extended periods of time, as for example spunbonded sheets made of synthetic polymer fibers. As used herein the term "polymer" generally includes but is not limited to, homopolymers, copolymers (such as for example, block, graft, random and alternating copolymers), terpolymers, etc. and blends and modifications thereof. Furthermore, unless otherwise specifically limited, the term "polymer" shall include all possible geometrical configurations of the

material. These configurations include, but are not limited to isotactic, syndiotactic and random symmetries.

Particularly well suited for making the barrier sheet material of the invention are substantially flat sheets of spunbonded nonwoven polyolefin film-fibrils of the type disclosed in U.S. Patent No. 3,169,899. Such spunbonded sheets preferably have been thermally bonded as disclosed in U.S. Patent No. 3,532,589, or have been calender bonded, as disclosed in PCT Publication No. WO 97/40224, in order to provide desired air barrier, water barrier, moisture vapor transmission, and strength properties. U.S. Patent Nos. 3,169,899 and 3,532,589, and PCT Publication No. WO 97/40224, are each incorporated herein by reference. The term "polyolefin" is intended to mean any of a series of largely saturated open chain polymeric hydrocarbons composed only of carbon and hydrogen. Typical polyolefins include, but are not limited to, polyethylene, polypropylene, polymethylpentene and various combinations of the monomers ethylene, propylene, and methylpentene. The term "polyethylene" is intended to embrace not only homopolymers of ethylene but also copolymers wherein at least 85% of the recurring units are ethylene units. A preferred polyethylene polymer is a homopolymeric linear polyethylene which has an upper melting range limit of about 130° to 135° C, a density in the range of 0.94 to 0.98 g/cm^3 and a melt index (as defined by ASTM D-1238-57T, Condition E) of 0.1 to 6.0. The term "polypropylene" is intended to embrace not only homopolymers of propylene but also copolymers wherein at least 85% of the recurring units are propylene units.

A particularly preferred flat sheet for making the barrier sheet material of the present invention is TYVEK® spunbonded polyethylene sheet that has been thermal calender bonded as disclosed in PCT Publication No. WO 97/40224 to provide a flat sheet with the following properties:

- a basis weight of about 61 g/m^2 (1.8 oz/yd^2)
- a moisture vapor transmission rate, measured according to the LYSSY method, of about 700 g/m^2 in 24 hrs;
- a hydrostatic head of about 240 cm;
- a Gurley Hill porosity of greater than 500 seconds;
- a tensile strength of about 49 N/cm (28 lbs/in) in the machine direction and 49 N/cm (28 lbs/in) in the cross direction;
- an Elmendorf tear strength of about 8 N in the machine direction and 8 N in the cross direction; and
- an elongation of about 12% in the machine direction and 16% in the cross direction.

The preferred flat sheet material described above has a moisture vapor transmission rate that is lower than is conventionally found in TYVEK® HOMEWRAP™ sheet products. The moisture vapor transmission rate ("MVTR") of the flat sheet should be selected so as to obtain a desired end product MVTR after texturing has been completed. For example, the flat sheet is intentionally bonded to obtain a low moisture vapor transmission rate where the channel means is to be provided by means of creping the flat sheet because the creping process increases the moisture vapor transmission rate of the sheet material. TYVEK® spunbonded polyethylene sheet has the advantage that it does not rot or otherwise readily break down under the temperature and humidity conditions normally encountered when used within the walls of a structure.

The embodiment of the barrier sheet material of the invention shown in Figure 2 is formed by creping a flat sheet material like that described above. The sheet material can be creped by conventional creping methods. A preferred method for creping a flat spunbonded fibrous sheet is shown in Figure 4 and is fully described in U.S. Patent No. 4,090,385, which is hereby incorporated by reference. According to this method, a flat sheet 30 is fed from a supply roll (not shown) to a main roll 32 having either a flat surface or a grooved surface. A primary surface 34 presses the flat sheet 30 against the main roll 32. A pressure plate 39 applies a constant pressure to the flat sheet 30. A creping blade is positioned in front of the path of the flat sheet. A flat creping blade is used with a flat roll and a combed blade is used with a grooved roll. Where the creping blade is combed as shown in Figure 4, each tooth 36 on the comb 37 has a tip that extends into one of the grooves 38 on the surface of the main roll 32.

After the flat sheet 30 passes the end of the primary surface 34, the sheet runs into the teeth of the comb 37 which slow the sheet 30 down and cause the sheet to bunch up and form a wavy grooved sheet 40. The amplitude, the waves (crest to trough), and the length of the waves in the wavy grooved sheet 40 are initially determined by the amount of space between the surface of the main roll 32 and a flexible retarder 42 and the space between the crepe blade and the flexible retarder 42. The amplitude and length of the waves in the grooved sheet 42 is further adjusted by adjusting the speed of the take-up roll (not shown). The speed of the take-up roll is some fraction of the speed of the supply roll and the main roll 32. As the speed of the take-up roll gets closer to the speed of the supply and main rolls, the amplitude of the waves in the grooved sheet becomes smaller and the length of the waves becomes longer.

The grooved barrier sheet 40 shown in Figure 2 was textured using the creping process shown in Figure 4. The basis weight of the sheet was increased from about 61 g/m^2 to about 68 g/m^2 by the creping process. The sheet material maintains its thickness 47 (Figure 5) at between about 100 microns and 125 microns (4 and 5 mils). The amplitude 48 of the waves in the sheet 40 is preferably between about 0.2 mm and 1.0 mm (8 and 40 mils) and the wave length 49 of the waves in the sheet 40 is preferably between about 3 mm and about and about 8 mm. The channels between wave peaks form essentially contiguous channels that run the full width (cross direction) of the sheet material on each side of the sheet material. According to one preferred embodiment of the invention, grooved barrier sheet 40 has the following properties:

- a basis weight of about 68 g/m^2 (2.0 oz/yd^2)
- a moisture vapor transmission rate, measured according to the LYSSY method, of between about 800 and 1200 g/m^2 in 24 hrs;
- a hydrostatic head of about 200 cm;
- a Gurley Hill porosity of between about 260 and 300 seconds;
- a tensile strength of about 42 N/cm in the machine direction and 56 N/cm in the cross direction;
- an Elmendorf tear strength of about 11 N in the machine direction and 11 N in the cross direction; and
- an elongation of about 12% in the machine direction and 16% in the cross direction.

According to another embodiment of the invention, channels in the barrier sheet material can be made using a microstretching process. A process for microstretching a non-woven web is fully described in U.S. Patent No. 4,223,059 which is hereby incorporated by reference. In the microstretching process, a spunbonded sheet is passed between two geared rolls. The teeth of the two geared rolls intermesh such that the teeth of one of the rolls project into the grooves between the teeth of the other of the rolls. One preferred grooved barrier sheet was made from the TYVEK® spunbonded polyethylene sheet described above that had been thermal calender bonded as disclosed in PCT Publication No. WO 97/40224 to provide a flat sheet with the following properties:

- a basis weight of about 61 g/m^2 (1.8 oz/yd^2)
- a moisture vapor transmission rate, measured according to the LYSSY method, of about 600 g/m^2 in 24 hrs;

- a hydrostatic head of about 305 cm;
- a Gurley Hill porosity of about 1600 seconds;
- a tensile strength of about 50 N/cm (32 lbs/in) in the machine direction and 53 N/cm (30 lbs/in) in the cross direction;
- an Elmendorf tear strength of about 7.1 N in the machine direction and 7.5 N in the cross direction; and
- an elongation of about 11% in the machine direction and 14% in the cross direction.

The flat sheet was passed between passed two geared rolls that each had a length of 36 cm and a diameter of 20 cm. Each of the geared rolls was covered with 2.3 mm high teeth that extended the length of the roll. There were 16 teeth per inch (6.3 teeth per cm) on the surface of the rolls . The two geared rolls were aligned such that the end of the tooth of one roll extends 1.4 mm into the groove of the other roll. The sheet was fed between the rolls at a speed of about 15 meters per minute (50 feet/min). The basis weight of the microstretched sheet was increased from about 61 g/m^2 to about 63 g/m^2 by the microstretching process. The sheet material maintained its thickness 47 (Figure 5) at about 127 microns (5 mils). The amplitude 48 of the waves (Figure 5) in the sheet was about 508 mm (20 mils) and the wave length 49 of the waves in the sheet was about 2.1 mm. The channels between wave peaks form substantially continuous and contiguous channels that run the full width (cross direction) of the sheet material on each side of the sheet material. This microstretched grooved barrier sheet had the following properties:

- a basis weight of about 63.1 g/m^2 (1.86 oz/yd^2)
- a moisture vapor transmission rate, measured according to the LYSSY method, of between about 1100 g/m^2 in 24 hrs;
- a hydrostatic head of about 254 cm;
- a Gurley Hill porosity of about 800 seconds;
- a tensile strength of about 52.2 N/cm in the machine direction and 53.8 N/cm in the cross direction;
- an Elmendorf tear strength of about 7.9 N in the machine direction and 6.3 N in the cross direction; and
- an elongation of about 11.2% in the machine direction and 15.3% in the cross direction.

When the barrier sheet material of the invention is used in a siding-faced wall construction and nails are hammered through the sheet material, the pressure of the siding against the sheet material around the area where the nail passes through the barrier sheet flattens out and blocks the channels around the nail hole. Thus, one apparent benefit of the invention is that water moving down the barrier sheet on the siding side of the sheet is directed away from nail holes by blockages in the sheet channels in the area around the nail holes. The water finds its way to open channels that are away from nail holes. When the barrier sheet material of the invention is used with siding applications, water that gets into the space between the siding and the sheet material, the water will be drained from the wall by the force of gravity through the channels on the exterior side of the barrier sheet. In the event that water that finds its way between the barrier sheet and the structure, channels on the structure side of the sheet material can allow water to drain water from the wall. In addition, it is believed that the small amount of air space in the channels of the sheet material improves the distribution of moisture behind the barrier sheet which in turn improves the transmission of moisture vapor out from behind the barrier sheet. Thus, moisture vapor, which can cause condensation, is much less likely to build up on the structure side of the channeled barrier sheet.

Figure 6 shows the barrier sheet material of the invention incorporated into a stucco-faced wall construction 70. In the stucco-faced wall construction 70 shown in Figure 6, the studs 72 of the structure are covered with a sheathing material 73, such as plywood. The sheathing 73 is covered with a grooved barrier sheet 40 as shown in Figure 2. The barrier sheet may be glued, stapled, nailed, taped or otherwise mechanically fastened to the sheathing 73. A metal lath 78, such as a woven "chicken wire", is applied over the grooved barrier sheet 40 and attached to the sheathing 73 and/or the studs 72 with furring nails (not shown). A scratch coat 22 of stucco is applied over the wire lath 78 so that the stucco passes through the lath and contacts the grooved barrier sheet 40. After the scratch coat has had an opportunity to dry, an intermediate brown coat 24 of stucco is applied over the scratch coat 22. Once the brown coat has had an opportunity to dry, finish coat 26 of stucco is applied over the brown coat 24. If exterior color is desired, the finish coat 26 may be pigmented or the surface of the finish coat may be painted.

The grooved barrier sheet 40 provides a number of important benefits when used under stucco. The grooves in the surface of the barrier sheet facing the stucco make a textured surface to which stucco readily bonds. In addition, because fibers on the surface of the barrier sheet are loosened during creping,

microstretching or embossing of the barrier sheet, the creped sheet has more loose fibers to which the stucco bonds. The good bond formed between the stucco and the barrier sheet helps to prevent a gap from forming between the stucco and the bonded sheet as frequently happens when stucco is coated over a flat paper barrier sheet. Thus, water that passes through cracks or pores in the stucco surface is stopped by the barrier sheet before it gets behind the stucco where it is believed that the water causes damage to the stucco.

Another important benefit of using the grooved barrier sheet 40 shown in Figure 2 behind stucco is that the creped barrier sheet 40 can expand and contract in an accordion-like fashion when stucco bonded to the surface of the barrier sheet expands or contracts. This is especially important during the period when the stucco is curing when the barrier sheet's flexibility prevents much of the cracking that is frequently encountered during the curing of a stucco surface. In addition, because the preferred barrier sheet 40 is a synthetic sheet that does not absorb water from the curing stucco, as occurs when an asphalt saturated kraft paper is used as the barrier sheet, cracking resulting from dehydrating the stucco too quickly is also avoided. Also, because the preferred synthetic barrier sheet 40 does not absorb water, the sheet does not buckle during the stucco curing process, which buckling contributes to cracking of the stucco applied over water-absorbing building papers. One other advantage of the preferred barrier sheet of the invention is that it is white and therefore does not heat up in the sun nearly as much as is the case with asphalt saturated papers. If the barrier sheet material is cooler at the time the stucco is applied, crack inducing rapid dehydration of the stucco is less likely to occur.

In stucco faced walls, another important advantages of the grooved barrier sheet 40 is that the barrier sheet has vertically oriented air channels behind the barrier sheet through which water can drain from the wall. If bulk water somehow finds its way behind the barrier sheet, the water will be drained from the wall through the channels by the force of gravity. In addition, it is believed that the small amount of air space in the channels behind the sheet material improves the the distribution of moisture behind the barrier sheet, which in turn is believed to improve the transmission of moisture vapor out through the barrier sheet. Without wishing to be bound by theory, it is believed that the channel air space helps to spread moisture vapor coming out of the structure over a wider area of the barrier sheet such that the water vapor can more readily be transmitted out through the sheet and stucco. In addition, some moisture vapor is believed to actually pass out of the channels without having to pass through the barrier sheet and the stucco.

In instances where the stucco is wet, as for example after a heavy rain, moisture vapor in the stucco can diffuse through the barrier sheet into the air channels between the backsheet and the sheathing of the structure. Accordingly, bulk water in the wall and moisture vapor in the stucco or the wall are more readily passed out of the walls. This more rapid discharge of water and water vapor from the wall reduces the rot, mold and mildew in stucco-faced walls. The air channels between the barrier backsheet and the remainder of the wall also have been found to form an effective break that helps prevent the transfer of moisture by capillary action from a wet exterior layer of a wall to the wall's sheathing, studs and insulation.

The grooved barrier sheet of the invention can also be incorporated into hybrid systems or Exterior Insulation and Finish Systems ("EIFS"), as shown in Figure 7. In an EIFS construction, the grooved barrier sheet 40 is used as the moisture barrier between the structure and a foam board 80. A fiberglass mesh 81 is attached to the outside of the foam board 80. A base coat 82 is applied over the fiberglass mesh and a finish coat 84 is applied over the base coat 82. In a hybrid system the fiberglass mesh 81 is replaced with metal lath. The grooved barrier sheet provides a means of escape for water and water vapor trapped between the foam board and the rest of the structure. When the grooved barrier sheet of the invention is used in an EIFS stucco construction, it is not necessary to cut channels in the foam boards or insert a drainage mat between the foam board and the barrier sheet, as discussed in the background section above.

Another beneficial property of the barrier sheet material of the invention is that the material is more durable than a flat barrier sheet material with similar strength properties. When a barrier sheet material is applied directly to the studs of a structure's frame, the barrier sheet material is easily ripped off the structure by wind until the outer layers of the structure's exterior walls are completed. It has been found that the grooved barrier sheet according to the invention can withstand a higher wind load without being torn off the studs than is possible with a flat sheet of the same material that has not been grooved. It is believed that the grooved barrier sheet material can withstand these greater wind loads because the grooved structure makes the sheet more flexible and resilient than a flat sheet.

The following non-limiting examples are intended to illustrate the invention and not to limit the invention in any manner.

EXAMPLES

In the description above and in the non-limiting examples that follow, the following test methods were employed to determine various reported characteristics and properties. ASTM refers to the American Society for Testing and Materials, TAPPI refers to the Technical Association of Pulp and Paper Industry, AATCC refers to the American Association of Textile Chemists and Colorists, and ISO refers to the International Organization for Standardization.

Basis weight was determined by ASTM D-3776, which is hereby incorporated by reference, and is reported in g/m^2.

Sheet Thickness was determined by ASTM method D 1777-64, which is hereby incorporated by reference, and is reported in microns.

Tensile strength was determined by ASTM D 1682, Section 19, which is hereby incorporated by reference, with the following modifications. In the test, a 2.54 cm by 20.32 cm (1 inch by 8 inch) sample was clamped at opposite ends of the sample. The clamps were attached 12.7 cm (5 in) from each other on the sample. The sample was pulled steadily at a speed of 5.08 cm/min (2 in/min) until the sample broke. The force at break was recorded in Newtons/2.54 cm as the breaking tensile strength. The area under the stress-strain curve was the work to break.

Elongation of a sheet is a measure of the amount a sheet stretches prior to failure (breaking) in a strip tensile test. A 1.0 inch (2.54 cm) wide sample is mounted in the clamps - set 5.0 inches (12.7 cm) apart - of a constant rate of extension tensile testing machine such as an Instron table model tester. A continuously increasing load is applied to the sample at a crosshead speed of 2.0 in/min (5.08 cm/min) until failure. The measurement is given in percentage of stretch prior to failure. The test generally follows ASTM D1682-64.

Elmendorf Tear Strength is a measure of the force required to propagate a tear cut in a sheet. The average force required to continue a tongue-type tear in a sheet is determined by measuring the work done in tearing it through a fixed distance. The tester consists of a sector-shaped pendulum carrying a clamp that is in alignment with a fixed clamp when the pendulum is in the raised starting position, with maximum potential energy. The specimen is fastened in the clamps and the tear is started by a slit cut in the specimen between the clamps. The pendulum is released and the specimen is torn as the moving clamp moves away from the fixed clamp. Elmendorf tear strength is measured in Newtons in accordance with the following standard methods: TAPPI-T-414 om-88 and ASTM D 1424, which are hereby incorporated by reference. The tear strength

values reported for the examples below are each an average of at least twelve measurements made on the sheet.

Hydrostatic Head is a measure of the resistance of the sheet to penetration by liquid water under a static load. A 7x7 in (17.78x17.78 cm) sample is mounted in a SDL 18 Shirley Hydrostatic Head Tester (manufactured by Shirley Developments Limited, Stockport, England). Water is pumped against one side of a 102.6 cm^2 section of the sample at a rate of 60 +/- 3 cm/min until three areas of the sample are penetrated by the water. The measured hydrostatic pressure is measured in inches, converted to SI units and given in centimeters of water. The test generally follows AATCC-127 or IOS811.

Moisture Vapor Transmission Rate (MVTR) is determined by ASTM E398-83 (which has since been withdrawn), which is hereby incorporated by reference. MVTR is reported in $g/m^2/24$ hr. MVTR data acquired by ASTM E398-83 was collected using a Lyssy MVTR tester model L80-4000J and is identified herein as "LYSSY" data. Lyssy is based in Zurich, Switzerland. MVTR test results are highly dependent on the test method used and material type. Important variables between test methods include the water vapor pressure gradient, volume of air space between liquid and sheet sample, temperature, air flow speed over the sample and test procedure. ASTM E398-83 (the "LYSSY" method) is based on a vapor pressure "gradient" of 85% relative humidity ("wet space") vs. 15% relative humidity ("dry space"). The LYSSY method measures the moisture diffusion rate for just a few minutes and under a constant humidity delta, which measured value is then extrapolated over a 24 hour period. The LYSSY method provides a higher MVTR value than ASTM E96, Method B for a moisture permeable fabric like the barrier sheet material of the invention.

Gurley Hill Porosity is a measure of the air permeability of the sheet material for gaseous materials. In particular, it is a measure of how long it takes for a volume of gas to pass through an area of material wherein a certain pressure gradient exists. Gurley-Hill porosity is measured in accordance with TAPPI T-460 om-88 using a Lorentzen & Wettre Model 121D Densometer. This test measures the time required for 100 cubic centimeters of air to be pushed through a one inch diameter sample under a pressure of approximately 125 mm of water. The result is expressed in seconds and is usually referred to as Gurley Seconds.

Length Loss is measured by measuring the length of a printed pattern in a direction perpendicular to sheet folds on a sheet and comparing the measured length against the length of the pattern prior to texturing. The percent length loss is equal to (the original length - the textured length)/(the original length).

Cement Slump is measured according to ASTM C143-90a (Slump Measurement of Hydraulic Cement Concrete) modified for stucco by using a 6 inch high cone instead of a 12 inch high cone. Slump is expressed in inches.

Sand Quality is measured according to ASTM 144 and is reported as a Sand Equivalent ("SE").

EXAMPLES 1-7A

In Examples 1-7A, grooved barrier sheet material was prepared by means of the creping process shown in Figure 4 and described above. Spunbonded sheets of flashspun polyethylene plexifilamentary film-fibrils, as disclosed in U.S. Patent No. 3,169,899, were bonded on a thermal calender bonder as disclosed in PCT Publication No. WO 97/40224 to obtain flat bonded sheets with one of the following sets of properties:

Sheet Type	A	B	C	D	E	F*
Basis Weight (g/m^2)	61	61	61	61	61	61
Thickness (microns)	137	140	165	145	163	127
MVTR-LYSSY	695	653	475	215	900	600
Hydrostatic Head (cm)	239	218	229	305	203	305
Gurley Hill Porosity (sec)	1360	943	826	>3000	220	1600
Tensile Strength-MD (N/cm)	56	56	49	54	40	50
Tensile Strength-CD (N/cm)	67	63	51	60	49	53
Elongation-MD (%)	14	12	9	11	8	11
Elongation-CD (%)	16	16	12	15	13	14
Elmendorfl Tear-MD (N)	7.6	8.9	11.6	10.7	10.5	7.1
Elmendorf Tear-CD (N)	6.7	8.5	9.3	8.5	9.4	7.5

**Data represents average properties of sheet produced over several months.*

The flat sheets described above were creped as described in U.S. Patent No. 4,090,385 according the creping conditions listed in Table 1 below. The "roll surface" of the crepe roll is either flat or grooved. A flat crepe roll is used with a flat creping blade while a "grooved" roll surface is used with a "comb" creping blade. The blade setting specifies the dimensions of the primary surface and the spacing of the retarder blade from the crepe roll surface. In setting 1, the primary surface was 0.030 mils thick and the retarder blade was 0.005 mils thick. In setting 2, the primary surface was 0.020 mils thick and the retarder blade was 0.005 mils thick. In addition, in setting 2, a 0.005 mils thick secondary retarder blade was spaced 0.010 mils above the primary retarder blade. In setting 3, the

primary surface was 0.030 mils thick and the retarder blade was 0.005 mils thick. In addition, in setting 3, a 0.005 mils thick secondary retarder blade was spaced 0.010 mils above the primary retarder blade.

The creped barrier sheets had the physical properties listed in Table 1 below.

Table 1

EXAMPLE	1	2	3	4
Sheet Type	A	A	A	A
Creping Process Conditions				
Roll Surface	Flat	Grooved	Grooved	Flat
Blade	Flat	Grooved	Combed	Flat
Roll Temperature (°C)	68	71	68	68
Blade Setting	3	3	3	3
Product Properties				
Basis Weight (g/m^2)	68	68	68	73
Amplitude of Grooves (microns)	737	940	406	1143
Length Loss (%)	28	16	13	19
MVTR-LYSSY (g/m^2/24 hr)	747	1163	924	--
Hydrostatic Head (cm)	223	201	231	247
Gurley Hill Porosity (sec)	250	458	330	207
Tensile Strength-MD (N/cm)	42	35	40	47
Tensile Strength-CD (N/cm)	70	54	51	58
Elongation-MD (%)	13	13	11	14
Elongation-CD (%)	17	14	15	18
Elmendorf Tear-MD (N)	10.7	11.6	7.6	7.1
Elmendorf Tear-CD (N)	12.9	12.0	11.6	10.7

Table 1 (continued)

EXAMPLE	5	6	7	7A*
Sheet Type	A	A	D	F
Creping Process Conditions				
Roll Surface	Flat	Flat	Flat	Flat
Blade	Flat	Flat	Flat	Flat
Roll Temperature (°C)	90	68	25	68
Blade Setting	3	3	1	3
Product Properties				
Basis Weight (g/m^2)	73	71	68	75
Amplitude of Grooves (microns)	1092	457	675	1066
Length Loss (%)	13	14	21	15
MVTR-LYSSY (g/m^2/24 hr)	1331	1012	847	1250
Hydrostatic Head (cm)	208	231	305	185
Gurley Hill Porosity (sec)	73	200	979	300
Tensile Strength-MD (N/cm)	44	51	49	49
Tensile Strength-CD (N/cm)	66	58	66	50
Elongation-MD (%)	13	13	16	13.5
Elongation-CD (%)	18	17	20	14
Elmendorf Tear-MD (N)	--	8.5	--	9.3
Elmendorf Tear-CD (N)	--	10.7	--	9.8

**Data represents average properties of sheet produced over several months.*

EXAMPLES 8 and 9

Two stucco-faced wall constructions were made and tested as described in Examples 8 and 9. The stucco-faced wall construction of Example 8 was made with the creped sheet material of Example 5 as the barrier sheet. The stucco-faced wall construction of Example 9 was made with the flat sheet Type E of Examples 1-7A as the barrier sheet.

The wall sections made for Examples 8 and 9 were built to simulate open frame construction (shown in Figure 1). Two wall frame sections that were each 8 feet wide and 6 feet high (2.44 meters wide and 1.83 meters wide) were built with 7 vertical 2x4 wood studs arranged on 16 inch (40.6 cm) centers. Horizontal steel wires were attached to the vertical studs of each frame and were

spaced about every six inches (15.2 cm) from the bottom to the top of the wall sections. On the wall section of Example 8, the creped barrier sheet of Example 5 was stapled to the frame over the steel wires with the fold and channels of the creped sheet oriented in a substantially vertical direction. The staples were spaced at 6 inch (15.2 cm) intervals. A 1.5 inch (3.8 cm) by 17 gauge self-furred hexagonal woven wire lath (chicken wire) was stapled over of barrier sheet of each frame through the barrier sheet approximately every 6 inches (15.2 cm). A galvanized steel weep screed was built into the bottom of each frame at the bottom of the barrier sheet.

A scratch coat of stucco was prepared by mixing 4.4 ft^3 (124.6 liters) of SE 49 sand (sand equivalent ("SE") measured according to ASTM 144), 1 ft^3 (28.3 liters) of Victor Plastic Cement from Southdown, Inc. of Brea, California, and 1.6 ft^3 (45.3 liters) of water. The stucco was mixed for 15 minutes and had a slump of 3.75 inches (9.5 cm). The scratch coat was applied over the barrier sheet and wire lath of each frame at a 3/8 inch (0.95 cm) thickness when the temperature was 22° C and the relative humidity was 65%. The scratch coat was dried for 2 days during which time the exposed surface was sprayed with a water mist approximately every 12 hours. After the two days of drying, the scratch coat was inspected for cracks and the relative humidity was measured on the front and back of the scratch coat. The moisture level was measured using a Lignomat K100 Moisture Meter (made by Lignomat of Portland, Oregon) with the sensitivity setting on 1 and the reference temperature set to 21° C. The moisture level in the back of the stucco was measured by inserting the moisture probe through the barrier sheet to reach the back of the scratch coat. The results are reported in Table 2 below.

A brown coat of stucco was then prepared by mixing 4.6 ft^3 (130.3 liters) of SE 49 sand, 1 ft^3 (28.3 liters) of Victor Plastic Cement from Southdown, Inc. of Brea, California, and 1.7 ft^3 (48.1 liters) of water. The stucco was mixed for 15 minutes and had a slump of 3.25 inches (8.26 cm). The brown coat was applied over the scratch coat at a 3/8 inch (0.95 cm) thickness when the temperatue was 29° C and the relative humidity was 59%. The brown coat was dried for 2 days during which time the exposed surface was sprayed with a water mist approximately every 12 hours. The relative humidity on the front of the brown coat and on the back of the scratch coat was measured as described in the paragraph above. After the two days of drying, the brown coat was inspected for cracks and the results are reported in Table 2 below.

Table 2

EXAMPLE	8	9
Barrier Sheet	Creped (from Ex. 5)	Flat - Type E
Scratch Coat		
Moisture content - front (%) (measured 1 hr after application at 24° C, 49% rel. humidity)	63	56
Moisture content - back (%) (measured 2 hr after application at 31° C, 24% rel. humidity)	43	39
Cracks after 2 days	none	none
Brown Coat		
Moisture content - front (%) (measured 1 hr after application at 24° C, 49% rel. humidity)	14	10
Moisture content - back of the scratch coat (%) (measured 2 hr after application of brown coat at 31° C, 24% rel. humidity)	17	15
Cracks after 2 days	none	small cracks at studs

EXAMPLES 10-11

Two stucco-faced wall constructions were made and tested as described in Examples 10 and 11. The stucco-faced wall construction of Example 10 was made with the creped sheet material of Example 5 as the barrier sheet. The stucco-faced wall construction of Example 11 was made with the flat Type E sheet (from Examples 1-7A) as the barrier sheet.

The wall sections made for Examples 10 and 11 were built to simulate sheathed frame construction (shown in Figure 6). Two sections of wooden exterior sheathing chipboard (2 ft x2 ft x 1 inch)(61 cm x 61 cm x 2.5 cm) were constructed and were covered with barrier sheet material. The barrier sheets were stapled to the chipboard sections with staples spaced about every six inches in the horizontal and vertical directions. In the construction of Example 10, the folds and channels of the creped sheet were oriented in a substantially vertical direction. A 1.5 inch (3.8 cm) by 17 gauge self-furred hexagonal woven wire lath ("chicken wire") was attached over of barrier sheet of each section using staples driven through the barrier sheet into the studs approximately every 6 inches.

A scratch coat of stucco was prepared by mixing 4.5 ft^3 (127.4 liters) of SE 49 sand (sand equivalent ("SE") measured according to ASTM 144), 1 ft^3 (28.3 liters) of Victor Plastic Cement from Southdown, Inc. of Brea, California, and 1.3 ft^3 (36.8 liters) of water. The stucco was mixed for 15 minutes and had an initial slump of 3.75 inches (9.53 cm). The scratch coat was applied over the barrier sheet and wire lath of each frame at a 5/8 inch (1.59 cm) thickness when the temperatue was 13° C and the relative humidity was 58%. The scratch coat was dried for 2 days under effective moist curing conditions (high humidity and regular rain). The samples were inspected for cracking after 1 day, 2 days and 10 days. The results are reported in Table 3 below.

Table 3

EXAMPLE	10	11
Barrier Sheet	Creped (from Ex. 5)	Flat - Type E
Scratch Coat		
Cracks after 1 day	none	15
Cracks after 2 days	none	6
Cracks after 10 days	1	22

EXAMPLES 12-13

Two hybrid type stucco-faced wall constructions were made and tested as described in Examples 12 and 13. The hybrid type stucco-faced wall construction of Example 12 was made with the creped sheet material of Example 7 as the barrier sheet. The hybrid type stucco-faced wall construction of Example 13 was made with the flat sheet Type D (that was used in making the creped sheet of Example 7) as the barrier sheet.

The wall sections made for Examples 12 and 13 were built to simulate one-coat hybrid stucco over sheathing board frame construction (as shown in Figure 7). Two 8 feet wide and 8 feet high wall frame sections (2.44 meters x 2.44 meters) were built that had 7 vertical 2x4 wooden studs arranged on 16 inch (40.6 cm) centers. Two sheets of wooden exterior sheathing chipboard (4 ft x 8 ft x 0.5 inch; 122 cm x 244 cm x 1.3 cm) were nailed onto the frame studs and were covered with the barrier sheet materials specified in the paragraph above. The barrier sheets nailed to the chipboard sections with roofing nails spaced about every six inches (15.2 cm) in the horizontal and vertical directions. In the

construction of Example 12, the folds and channels of the creped sheet were oriented in a substantially vertical direction.

Polystyrene foam sheets (4 ft x 8 ft x 1.5 in; 122 cm x 244 cm x 1.3 cm) were nailed over the barrier sheet material using plastic capped nails. A 1 inch (2.54 cm) x 13 gauge self-furred hexagonal woven wire lath was attached over the foam sheets. A galvanized steel weep screed was built into the bottom of each frame at the bottom of the barrier sheet.

A coat of a hybrid stucco was prepared by mixing 4.6 ft^3 (130.3 liters) of SE 55 sand (sand equivalent ("SE") measured according to ASTM 144), 1 ft^3 (28.3 liters)of Calveras Plastic Cement from Calveras Cement Corporation of San Francisco, California, 3 ft^3 (85.0 liters) of Fiberglass Base 3 Cement sold by Star Building Products of Fresno, California, and 2.1 ft^3 (59.5 liters) of water. The hybrid stucco was mixed for 15 minutes. The hybrid stucco was applied over the foam board and wire lath of each frame at a 3/8 inch (0.95 cm) thickness when the temperature was 33° C and the relative humidity was about 25%. The coat of hybrid stucco was moist cured for 48 hours, during which time the hybrid stucco was water misted approximately every 12 hours. The results are reported in Table 4 below.

Table 4

EXAMPLE	12	13
Barrier Sheet	Creped (from Ex. 7)	Flat - Type D
Hybrid Base Coat		
Cracks after 1 day	none	none
Cracks after 7 days	none	1

EXAMPLES 14-15

Two water barrier sheets were tested in a simulated wall construction to determine the sheet's capacity for draining water when incorporated into a wall construction. The sheet tested in Example 14 was made with the creped sheet material of Example 6 used as the barrier sheet. The sheet tested in Example 15 was made with the flat sheet Type A (that was used in making the creped sheet of Example 6) as the barrier sheet.

The two barrier sheets specified in the paragraph above were placed, one at a time, between a 24 inch x 17.5 inch (61.0 x 44.5 cm) piece of sheet metal

attached to a 16 inch x24 inch stud frame and a flat sheet of Plexiglas of similar dimension. Wood screws were used to tighten the Plexiglas sheet against barrier sheet and the sheet metal back. The wood screws were spaced every 16 inches (40.6 cm) in the horizontal directions and were spaced every 10 inches (25.4) over the studs in the vertical direction. Each screw was tightened to a torque of 30 inch-lbs (339 cm-N). This assembly was placed in a vertical orientation. The sheet metal at the top of the assembly was bent backwards away from the Plexiglas sheet to form a header box that holds a measured quantity of water over the space between the sheets of metal and Plexiglas where the barrier sheet is positioned. The assembly was sealed on its edges with sheathing tape and caulked at the corners of the header box to prevent leakage.

The barrier sheet extended into the header box and was bent back to follow the contour of the top of the metal sheet. Water was poured between the barrier sheet and the Plexiglas sheet so that water was passed between the Plexiglas sheet and the barrier sheet. The water drained out the bottom of the assembly and was collected in a pan. The time needed to pass a given amount of water through the assembly was measured. The timer was started as the first amount of water hit the sheet. The timer was stopped when the head of water reached the bottom off the Plexiglas sheet. If 15 minutes elapsed before all the water drained out, the amount collected is measured and a flow rate was calculated. The results are reported in Table 5 below.

Table 5

EXAMPLE	14	15
Barrier Sheet	Creped (from Ex. 6)	Flat - Type A
Time	1000 ml in 18 seconds	760 ml in 15 minutes
Flow Rate (liters/hr)	200	3

EXAMPLES 16-18

Three barrier sheet samples were tested in a tensile strength test as generally described above. The elongation at a load of 3 lbs (13.3N) was recorded for each sample and are listed in Table 6 below.

Table 6

EXAMPLE	16	17	18
Barrier Sheet	Flat-Type D	Flat-Type C	Creped-Example 7
Elongation (%)			
MD	0.39	0.53	0.88
CD	0.39	0.47	0.48

EXAMPLES 19 - 22

Traditional stucco-faced wall sections were made using three known flat barrier sheet materials (Exs. 19-21) as well as with a creped barrier sheet material according to one embodiment of the invention (Ex. 22). The wall sections were each dried, cured, and subjected to simulated rain and wind conditions. The wall sections were inspected for cracks in the stucco shortly after application of the stucco and again about four months after application of the stucco. The procedure for constructing and testing the wall sections is described below. The barrier sheet materials were as follows:

Example 19: Grade D asphalt saturated kraft paper with a basis weight of 305 g/m^2 (9 oz/yd^2) and a 60 minute rating.

Example 20: 15 pound asphalt saturated felt sheet, with a basis weight of 458 g/m^2 (13.5 oz/yd^2).

Example 21: TYVEK® Homewrap® polyethylene plexifilamentary sheet material more fully described in Examples 1-7A as Type E flat sheet material.

Example 22: The creped sheet material of Example 7.

The wall sections of Examples 19-22 were built to simulate open frame construction (shown in Figure 1). Each 8 foot by 8 foot (2.4 m x 2.4 m) wall section was built from vertical 2x4 inch wood studs arranged on 16 inch (40.6 cm) centers as shown in Figure 8. Each wall section was built with a window opening that was fitted with a 1.5 foot by 2 foot (45.7 cm x 61.0 cm) vinyl clad window sold by Anlin Industries of Fresno, California. The window was flashed with 6 inch wide (15.2 cm) paper flashing made by Fortifiber Corporation of Los Angeles, California. Horizontal steel wires were attached to one side of the vertical studs of each frame and were spaced about every six inches (15.2 cm) from the bottom to the top of the wall sections. Kraft-backed fiberglass insulation was inserted between the studs with the kraft paper backing of the insulation facing away from the horizantal wires. The insulation was covered with a 0.5 inch (1.27 cm) thick gypsum-based drywall material nailed to the side of the studs facing away for the horizontal wires. The drywall was

loosely covered with a sheet of polyethylene in order to protect the wall sections against rain intrusion into the wall from the drywall side of the wall sections.

One of the barrier sheet materials described above was fastened over the horizantal wires of each wall section. The barrier sheet was fastened to the studs at six inch (15.2 cm) intervals using furring nails. On the wall section of Example 22, the creped barrier sheet was nailed to the frame over the steel wires with the folds and channels of the creped sheet oriented in a substantially vertical direction. A 1.5 inch (3.8 cm) by 17 gauge self-furred hexagonal woven wire lath (chicken wire) was nailed over of barrier sheet of each frame with furring nails spaced approximately every 6 inches (15.2 cm) along the studs. A galvanized steel weep screed was built into the bottom of each frame at the bottom of the barrier sheet. In order to simulate actual construction conditions, the barrier sheets of each wall section were left exposed to the elements for approximately three weeks before stucco was applied over the barrier sheets.

A scratch coat of stucco was prepared by mixing sand, cement and water in a 12 gallon paddle mixer at the following proportions: 1 ft^3 (28.3 liters) of Calveras Plastic Cement sold by Calveras Cement Corporation of San Francisco, California, 2 ft^3 (56.6 liters) of SE 55 sand (sand equivalent ("SE") measured according to ASTM 144), and 1 ft^3 (28.3 liters) of water. The stucco was mixed for 10 to 15 minutes and had a slump of about 3 inches (7.6 cm). The scratch coat was applied by hand over the barrier sheet and wire lath of each frame at a 5/8 inch (1.53 cm) thickness when the temperature was about 32° C and the relative humidity was 25%. The scratch coat was moist cured for 2 days during which time the exposed surface was sprayed with a water mist approximately every 12 hours.

A brown coat of stucco was then prepared by mixing sand, cement and water in a 12 gallon paddle mixer at the following proportions: 1 ft^3 (28.3 liters) of Calveras Plastic Cement from Calveras Cement Corporation of San Francisco, California, 1.6 ft^3 (45.3 liters) of SE 55 sand, and 0.6 ft^3 (17.0 liters) of water. The stucco was mixed for about 10 minutes and had a slump of abour 3 inches (7.2 cm). Two days after application of the scratch coat, the brown coat of stucco was applied by hand over the scratch coat at a thickness of about 1/2 inch (1.3 cm) when the temperature was about 32° C and the relative humidity was 25%. The brown coat was moist cured for 2 days during which time the exposed surface was sprayed with a water mist approximately every 12 hours. This was followed by another six days of drying at daytime temperatures of about 32° C, after which the brown coat was inspected for cracks. The number of cracks

with a length longer than 2 inches (5.1 cm) that were present in the stucco of each wall are reported in Table 7 below.

After the cracks were counted as described above, a finish coat of Blue Eagle Exterior Stucco, made by Eagle Building Materials of Fresno, California was sprayed over the brown coat at a thickness of about 1/8 inch (0.32 cm). The finish coat was made using 3 parts of the Blue Eagle Exterior Stucco (which included both sand and cement) and 1 part water. After application of the finish coat, the walls were left exposed to the elements for approximately three months.

Approximately three months after application of the finish coat, each wall section was exposed to simulated rain and wind for 2.5 hours according to the method of ASTM E331. A special test box was made that could be clamped to the stucco side of the wall sections without requiring that the wall sections be moved. The box had a fan that generated a pressure against the wall sections so as to simulate the pressure from various wind speeds. The box also had spray nozzles that sprayed 5 gallons of water per hour (18.9 liters/hr) against each square yard of wall section. The water was sprayed against each wall for 2.5 hours. During the first 1.5 hours of the spray test, the fan applied a wind pressure of 0.3 inches (0.76 cm) of water, which is equivalent to pressure generated by a wind speed of 25 mile per hour (40.2 km/hr) directly against the wall. During the last hour of the spray test, the fan speed was increased so as to apply a wind pressure of 1.2 inches (3.0 cm) of water, which is equivalent to pressure generated by a wind speed of 50 mile per hour (80.5 km/hr) directly against the wall. The wall was then left to dry for two weeks.

After the two week drying period, each wall section was subjected to a second period of simulated wind and rain using the test box similar to the one described in the paragraph above. The second test period lasted for 10.5 hours during which time 5 gallons of water per hour (18.9 liters/hr) was sprayed against each square yard of wall section. During the first 1 hour period of the second test period, the fan was not turned on. During the next 1 hour of the second test period, the fan speed was increased so as to apply a wind pressure of 0.3 inches (0.76 cm) of water, which is equivalent to the pressure generated by a wind speed of 25 miles per hour (40.2 km/hr) directly against the wall. During the next 2.5 hours of the second test period, the fan speed was increased so as to apply a wind pressure of 1.2 inches (3.0 cm) of water, which is equivalent to the pressure generated by a wind speed of 50 miles per hour (80.5 km/hr) directly against the wall. During the next 1 hour of the second test period, the fan speed was increased so as to apply a wind pressure of 3 inches (7.6 cm) of water, which is equivalent to

the pressure generated by a wind speed of 80 miles per hour (128.8 km/hr) directly against the wall. During the next 1 hour of the second test period, the fan speed was increased so as to apply a wind pressure of 4 inches (10.2 cm) of water, which is equivalent to the pressure generated by a wind speed of 90 miles per hour (144.8 km/hr) directly against the wall. During the last 4 hours of the second test period, the fan speed was increased so as to apply a wind pressure of 5 inches (12.7 cm) of water, which is equivalent to pressure generated by a wind speed of 100 miles per hour (160.9 km/hr) directly against the wall. The wall was then left to dry for about 10 days at which time (about 4 months from brown coat application) each wall section was inspected for cracks. The number of cracks with a length longer than about 2 inches (5.1 cm) that were present in the stucco of each wall are reported in Table 7 below.

Table 7

EXAMPLE	19	20	21	22
Barrier Sheet	Asphalt-saturated kraft paper	15 # felt	Flat Sheet Type E	Creped Sheet -from Example 7
Cracks Observed 6 days after brown coat application	9	1	5	0
Cracks Observed 4 months after brown coat application	15	4	5	0

EXAMPLES 23 - 26

Hybrid stucco-faced wall sections were made using three known flat barrier sheet materials (Exs. 23-25) as well as with a creped barrier sheet material according to one embodiment of the invention (Ex. 26). The wall sections were each dried, cured, and subjected to simulated rain and wind conditions. The wall sections were inspected for cracks in the stucco shortly after application of the stucco and again about four months after application of the stucco. The procedure for constructing and testing the wall sections is described below. The barrier sheet materials were as follows:

Example 23: Grade D asphalt saturated kraft paper with a basis weight of 305 g/m^2 (9 oz/yd^2) and a 60 minute rating.

Example 24: 15 pound asphalt saturated felt sheet, with a basis weight of 458 g/m^2 (13.5 oz/yd^2).

Example 25: TYVEK® Homewrap® polyethylene plexifilamentary sheet material more fully described in Example 1-7A as Type E flat sheet material.

Example 26: The creped sheet material of Example 7.

The wall sections of Examples 23-26 were built to simulate a one coat hybrid wall construction. Each 8 foot by 8 foot (2.44 m x 2.44 m) wall section was built from identical to the wall sections of Examples 19-22 from vertical 2x4 inch wood studs arranged on 16 inch (40.6 cm) centers as shown in Figure 8. Each wall section was built with a window opening. Sheets of wooden exterior sheathing chipboard (4 ft x 8 ft x 0.5 inch)(1.2 m x 2.4 m x 1.3 cm) were nailed onto the frame studs but not over the window opening. A 1.5 foot by 2 foot (45.7 cm x 61.0 cm) vinyl clad window sold by Anlin Industries of Fresno, California was mounted in the window opening and the window was flashed with 6 inch (15.2 cm) wide paper flashing made by Fortifiber of Los Angeles, California. One of the barrier sheet materials specified above was then placed over the sheathing chipboard and fastened to the chipboard with roofing nails spaced about every six inches (15.2 cm) in the horizontal and vertical directions. A Kraft-backed fiberglass insulation was inserted between the studs with the kraft paper backing of the insulation facing away from the side of the wall section to which the stucco would be applied. The insulation was covered with a half inch (1.3 cm) thick gypsum-based drywall material nailed to the side of the studs facing away for the side that would be finished with stucco. The drywall was loosely covered with a sheet of polyethylene in order to protect the wall sections against rain intrusion into the wall from the drywall side of the wall sections.

In the wall section of Example 26, the folds and channels of the creped sheet were oriented in a substantially vertical direction. In order to simulate actual construction conditions, the barrier sheets of each wall section were left exposed to the elements for approximately three weeks before stucco was applied over the barrier sheets.

Polystyrene foam sheets (4 ft x 8 ft x 7/8 in)(1.2 m x 2.4 m x 2.2 cm) were nailed over the barrier sheet material using plastic capped nails. A 1 inch (2.54 cm) x 13 gauge self-furred hexagonal woven wire lath was attached over the foam sheets using the plastic capped nails. The plastic caps on the nails prevent the heads of the nails from being pulled through the foam sheets. A galvanized steel weep screed was built into the bottom of each frame at the bottom of the barrier sheet.

A coat of a hybrid stucco was prepared by mixing SE 55 sand (sand equivalent ("SE") measured according to ASTM 144), Calveras Plastic Cement from Calveras Cement Corporation of San Francisco, California, Fiberglass Base 3 Cement from Star Building Products of Fresno, California, and water in the following proportions: 4.6 ft^3 (130.0 liters) sand; 1 ft^3 (28.3 liters) plastic cement; 3 ft^3 (85.0 liters) fiberglass reinforced cement; and 2.1 ft^3 (59.5 liters) water. These components were mixed for 15 minutes. The hybrid stucco was applied over the foam board and wire lath of each frame at a 3/8 inch (0.95 cm) thickness when the temperature was about 33° C and the relative humidity was about 25%. The coat of hybrid stucco was moist cured for 48 hours, during which time the hybrid stucco was water misted approximately every 12 hours. This was followed by another eight days of drying at daytime temperatures of about 33° C, after which the hybrid stucco coat was inspected for cracks. The number of cracks with a length longer than 2 inches that were present in the stucco of each wall are reported in Table 8 below.

After the cracks were counted as described above, a finish coat of Blue Eagle Exterior Stucco, made by Eagle Building Materials of Fresno, California was sprayed over the brown coat at a thickness of about 1/8 inch (0.32 cm). The finish coat was made using 3 parts of the Blue Eagle Exterior Stucco (which included both sand and cement) and 1 part water. After application of the finish coat, the walls were left exposed to the elements for approximately three months.

Approximately three months after application of the finish coat, each wall section was exposed to simulated rain and wind for 2.5 hours according to the method of ASTM E331. A special test box was made that could be clamped to the stucco side of the wall sections without requiring that the wall sections be moved. The box had a fan that generated a pressure against the wall sections so as to simulate the pressure from various wind speeds. The box also had spray nozzles that sprayed 5 gallons of water per hour (18.9 liters/hr) against each square yard of wall section. The water was sprayed against each wall for 2.5 hours. During the first 1.5 hours of the spray test, the fan applied a wind pressure of 0.3 inches (0.76cm) of water, which is equivalent to pressure generated by a wind speed of 25 mile per hour (40.2 km/hr) directly against the wall. During the last hour of the spray test, the fan speed was increased so as to apply a wind pressure of 1.2 inches (3.0 cm) of water, which is equivalent to pressure generated by a wind speed of 50 mile per hour (80.5 km/hr) directly against the wall. The wall was then left to dry for two weeks.

After the two week drying period, each wall section was subjected to a second period of simulated wind and rain using the test box similar to the one described in the paragraph above. The second test period lasted for 10.5 hours during which time 5 gallons of water per hour (18.9 liters/hr) was sprayed against each square yard of wall section. During the first 1 hour period of the second test period, the fan not turned on. During the next 1 hour of the second test period, the fan speed was increased so as to apply a wind pressure of 0.3 inches (0.76 cm) of water, which is equivalent to the pressure generated by a wind speed of 25 miles per hour (40.2 km/hr) directly against the wall. During the next 2.5 hours of the second test period, the fan speed was increased so as to apply a wind pressure of 1.2 inches (3.0 cm) of water, which is equivalent to the pressure generated by a wind speed of 50 miles per hour (80.5 km/hr) directly against the wall. During the next 1 hour of the second test period, the fan speed was increased so as to apply a wind pressure of 3 inches (7.6 cm) of water, which is equivalent to the pressure generated by a wind speed of 80 miles per hour (128.8 km/hr) directly against the wall. During the next 1 hour of the second test period, the fan speed was increased so as to apply a wind pressure of 4 inches (10.2 cm) of water, which is equivalent to the pressure generated by a wind speed of 90 miles per hour (144.8 km/hr) directly against the wall. During the last 4 hours of the second test period, the fan speed was increased so as to apply a wind pressure of 5 inches (12.7 cm) of water, which is equivalent to pressure generated by a wind speed of 100 miles per hour (160.9 km/hr) directly against the wall. The wall was then left to dry for about 10 days at which time (about 4 months from brown coat application) each wall section was inspected for cracks. The number of cracks with a length longer than about 2 inches (5.1 cm) that were present in the stucco of each wall are reported in Table 8 below.

Table 8

EXAMPLE	23	24	25	26
Barrier Sheet	Asphalt-saturated kraft paper	15 # felt	Flat sheet - Type E	Creped Sheet from Ex. 7
Cracks Observed 6 days after hybrid coat application	0	0	0	0
Cracks Observed 4 months after hybrid coat application	6	2	2	0

EXAMPLES 27 - 28

The wall structures of Examples 21 and 22 were each tested for rain resistance by subjecting the wall structures to simulated wind and rain for 2.5 hours as described in Examples 21 and 22 above. A special test box was made that could be clamped to the stucco side of the wall sections without requiring that the wall sections be moved. The box had a fan that could simulate various wind speeds and spray nozzles that sprayed 5 gallons of water per hour (18.9 liters/hr) against each square yard of wall section. The water was sprayed against each wall for 2.5 hours. During the first 1.5 hours of the spray test, the fan applied a wind pressure of 0.3 inches (0.76 cm) of water, which is equivalent to pressure generated by a wind speed of 25 mile per hour (40.2 km/hr) directly against the wall. During the last hour of the spray test, the fan speed was increased so as to apply a wind pressure of 1.2 inches (3.0 cm) of water, which is equivalent to pressure generated by a wind speed of 50 miles per hour (80.5 km/hr) directly against the wall.

The drywall and insulation were removed from the wall structures in order to permit observation of the back of the barrier material. Moisture measurements were taken on the back of the barrier sheet every half hour over the course of the test. Moisture measurements were taken on the backside of the barrier sheet at the 13 points (A-M) shown in Figure 8 using a Woodfriendly™ Wagner Moisture Meter Model L607. An average of the 13 readings from points A-M are reported in Table 9 below. An average of just the six moisture measurements taken below the window (H-M) are also reported in Table 9 below.

Table 9

Time (hours)	Ex. 27 (flat sheet; Avg. % Moisture for Points A-M)	Ex. 28 (creped sheet; Avg. % Moisture for Points A-M)	Ex. 27 (flat sheet; Avg. % Moisture for Points H-M)	Ex. 28 (creped sheet; Avg. % Moisture for Points H-M)
0	13	11	11	9
0.5	15	11	12	9
1.0	16	13	13	10
1.5	18	14	14	11
2.0	19	16	17	12
2.5	23	17	23	14

EXAMPLES 29 - 34

Six traditional stucco-faced wall sections were made and tested for cracking resistance and moisture loss as described below. In Examples 29 and 32,

the wall sections were made with the creped barrier sheet material used in Example 22 as the barrier sheet material. In Examples 30 and 33, the wall sections were made with the flat barrier sheet material used in Example 21 as the barrier sheet material. In Examples 31 and 34, the wall sections were made with the asphalt saturated kraft paper of Example 19 as the barrier sheet material. The wall sections of Examples 29 - 31 were plastered with stucco scratch and brown coats made using good quality sand with few impurities. The wall sections of Examples 32 - 34 were plastered with stucco scratch and brown coats made using poor quality sand that included water absorbing impurities.

The wall sections of Examples 29 - 34 were built to simulate open frame construction (shown in Figure 1). Each 6 foot by 8 foot (1.8 m x 2.4 m) wall section was built from vertical 2x4 inch wood studs arranged on 16 inch (40.6 cm) centers as shown in Figure 9. Horizontal steel wires were attached to one side of the vertical studs of each frame and were spaced about every six inches from the bottom to the top of the wall sections. In Examples 29 and 32, the creped barrier sheet material used in Example 22 was fastened over the horizantal wires of each wall section. In Examples 30 and 33, the flat barrier sheet material used in Example 21 was fastened over the horizantal wires of each wall section. In Examples 31 and 34, the asphalt saturated kraft paper barrier sheet material of Example 19 was fastened over the horizantal wires of each wall section. The barrier sheet material was fastened to the studs at six inch (15.2 cm) intervals using furring nails. The creped barrier sheet used in Examples 29 and 32 was nailed to the frame over the steel wires with the folds and channels of the creped sheet oriented in a substantially vertical direction. A 1.5 inch (2.54 cm) by 17 gauge self-furred hexagonal woven wire lath (chicken wire) was nailed over of barrier sheet of each frame with furring nails spaced approximately every 6 inches (15.2 cm) along the studs. A galvanized steel weep screed was built into the bottom of each frame at the bottom of the barrier sheet.

Stucco scratch coats were prepared using good and poor quality sands. The good quality sand was a well washed SE 87 sand with very few impurities. The poor quality sand was an unwashed SE 49 sand that included a variety of impurities. The stucco was prepared by mixing the sand, Victor Plastic Cement sold by Southdown Inc. of Brea, California, and water in a 12 gallon paddle mixer at the following proportions:

Mix	Coat	Sand Quality	Sand (ft^3)	Plastic Cement (ft^3)	Water (ft^3)	Mixing time (min)	Slump (inches)
1	Scratch	Poor	4.4	1.0	1.6	10	3.75
2	Scratch	Good	3.7	1.0	0.7	10	2.75

(1 ft^3 = 28.3 liters; 1 inch = 2.54 cm)

The scratch coat was applied by hand over the barrier sheet and wire lath of each wall section at a 3/8 inch (0.95 cm) thickness when the temperature was about 22° C and the relative humidity was 65%. The scratch coat was moist cured for 2 days during which time the exposed surface was sprayed with a water mist approximately every 12 hours. Two days after application of the scratch coat, the brown coat of stucco was applied by hand over the scratch coat at a thickness of about 3/8 inch (0.95 cm) when the temperature was about 29° C and the relative humidity was 59%. The moisture level in the scratch coat was measured using a Lignomat K100 moisture meter at the points A-L shown in Figure 9. At one hour and seven hours after application of the stucco, the moisture level in the front exposed surface of the stucco was measured at points A - L. At two hours and seven hours after application of the stucco, the moisture level in the back of the stucco in the region near the barrier sheet was measured at points A - L by penetrating the barrier sheet with the probe of the moisture meter. The average of the moisture measurements and cracking observations are reported in Table 10 below.

Table 10

Example	Barrier	Sand Quality	Moisture - Front @ 1 hr (%)	Moisture - Back @ 2 hr (%)	Moisture - Front @ 7 hr (%)	Moisture - Back @ 7 hr (%)	Scratch Coat Cracking after 2 days
29	Creped	Good	60	54	10	19	none
30	Flat	Good	56	38.5	10	14	none
31	Paper	Good	31	38.5	9	9	hundreds
32	Creped	Poor	63	43	14	17	none
33	Flat	Poor	56	39	10	15	none
34	Paper	Poor	45	33	9	9	thousands

Stucco brown coats were prepared using good and poor quality sands. The good quality sand was a well washed SE 87 sand with very few impurities. The poor quality sand was an unwashed SE 49 sand that included a variety of impurities. The stucco was prepared by mixing the sand, Victor Plastic Cement

from Southdowne Inc. of Brea, California, and water in a 12 gallon paddle mixer at the following proportions:

Mix	Coat	Sand Quality	Sand (ft^3)	Plastic Cement (ft^3)	Water (ft^3)	Mixing time (min)	Slump (inches)
3	Brown	Poor	4.7	1.0	1.7	15	3.25
4	Brown	Good	5.0	1.0	0.9	15	2.75

(1 ft^3 = 28.3 liters; 1 inch = 2.54 cm)

The brown coat was applied by hand over the scratch coat of each wall section at a 3/8 inch (0.95 cm) thickness when the temperature was about 29° C and the relative humidity was 59%. The poor quality brown coat (Mix 3) was applied to the wall sections that were made with the poor quality scratch coats (Examples 32 - 34) and the good quality brown coat (Mix 4) was applied to the wall sections that were made with the good quality scratch coats (Examples 29 - 31). The brown coat was moist cured for 2 days during which time the exposed surface was sprayed with a water mist approximately every 12 hours. The moist curing was followed by another 6 days of drying at daytime temperatures of about 25° C, after which the brown coat was inspected for cracks. The number of cracks with a length longer than 2 inches that were present in the stucco of each wall are reported in Table 11 below.

Table 11

Example	Barrier	Sand Quality	Brown Coat Cradking after 6 days
29	Creped	Good	none
30	Flat	Good	none
31	Paper	Good	none
32	Creped	Poor	none
33	Flat	Poor	<5
34	Paper	Poor	several

EXAMPLES 35 - 37

Three one half inch OSB sheet boards were cut in the form of squares measuring 2 feet by 2 feet (61 cm x 61 cm). A sheet of the asphalt saturated kraft paper of Example 23 was stapled every 6 inches (15.2 cm) in the horizontal and vertical directions to the first OSB board for Example 35. Two sheets of the

asphalt saturated kraft paper of Example 23 was stapled every 6 inches (15.2 cm) in the horizontal and vertical directions to the second OSB board for Example 36. A sheet of the creped spunbonded sheet material of Example 26 was stapled every 6 inches (15.2 cm) in the horizontal and vertical directions to the third OSB board for Example 37. A 1.5 inch (3.8 cm) by 17 gauge self-furred hexagonal woven wire lath (chicken wire) was stapled over the barrier sheet covering each board. The staples were spaced approximately every 6 inches (15.2 cm) in the vertical and horizontal directions.

A stucco scratch coat was prepared using a poor quality unwashed SE 49 sand that included a variety of impurities. The stucco was prepared by mixing the sand, Victor Plastic Cement from Sothdown of Brea, California, and water in a 12 gallon paddle mixer at the following proportions: 4.5 ft^3 (127.4 liters) and; 1.0 ft^3 (28.3) Plastic Cement; 1.3 ft^3 36.8 liters) water. The stucco had a slump of about 3.75 inches (9.5 cm). The scratch coat was applied by hand over the barrier sheet and wire lath of each wall section at a 5/8 inch (1.58 cm) thickness when the temperature was about 13° C and the relative humidity was 58%. The scratch coat was air dried for two weeks and then inspected for cracking. The number of cracks observed that were two inches or longer in length were as follows:

Example 35 (single sheet kraft paper):	17 cracks
Example 36 (double sheet kraft paper):	24 cracks
Example 37 (creped spunbond):	1 crack

EXAMPLE 38

Nine different barrier sheets were tested in a drainage testing unit in order to evaluate the relative drainage performance of the sheet materials. The drainage testing unit is shown in Figure 10. The testing unit included two plexiglass panels that were 9.875 inches (25.1 cm) tall, 8.1875 inches (20.8 cm) wide, and 0.35 inches (0.89 cm) thick. The front panel 90 had a trough opening 93 that was 1.8 inches (4.6 cm) wide centered at the top edge of the front panel 90. Sheet of barrier materials were inserted between the panels 90 and 91 in a manner such that the top edge of the sample aligned with the top edge of panel 91 and the vertical midline of the sample was centered in the trough opening 93. Four clamps 95 held the panels together with a force of about 50 pounds (222 N). The two top clamps were positioned 0.3125 inches (0.79 cm) in from the edges of the panels and 0.875 inches (2.2 cm) down from the top of the panels. The two bottom clamps were positioned 0.3125 inches (0.79 cm) in from the edges of the panels and 5 inches (12.7 cm) down from the top of the panels. The clamped

plexiglas panels 90 and 91 fit in a collection base 96 that holds the plexiglas panels about 2.5 inches (6.4 cm) above the bottom of the collection base so as to permit liquid between the panels to drain out of the panels.

The nine barrier sheet materials listed below were tested one at a time in the drainage testing unit described in the paragraph above according to the following procedure ("the Barrier Sheet Drainage Test Method"). For each test, a barrier sheet material sample was clamped in the drainage testing unit as described above. Twenty milliliters of water was poured into the trough opening such that water was passed between the panel 90 and the barrier sheet material. The water drained out the bottom of the panels and was collected in the collection base. The time needed to pass a given amount of water through the assembly was measured. The timer was started as the water was first poured into the trough opining. The timer was stopped when the top surface of the water reached the bottom off the panels. If 15 minutes elapsed before all the water drained out, the amount of water collected was measured and a flow rate was calculated. The results are reported in Table 12 below in units of milliliters per hour per inch width of sheet material.

Barrier Sheet A - An 8 inch by 10 inch (20.3 cm x 25.4 cm) sample of a Grade D asphalt saturated kraft paper with a basis weight of 9.0 oz/ yd^2 (305 g/m^2) and a 60 minute rating, manufactured by Leatherback Industries of Hollister, California.

Barrier Sheet B - An 8 inch by 10 inch (20.3 cm x 25.4 cm) sample of a flat spunbonded polyethylene plexifilamentary sheet material more fully described in Example 1 as Type E (sold as TYVEK® Homewrap®).

Barrier Sheet C - A 2 inch by 10 inch (5.1 cm x 25.4 cm) sample of a spunbonded polyethylene plexifilamentary sheet more fully described in Example 1 as Type E (sold as TYVEK® Homewrap®) that had been embossed with a diamond pattern. The embossing was done at a speed of 2.5 cm/sec using a 10 cm wide embossing roll having a diameter of 8 cm that was heated to 65° C, and was pressed against an 8 cm hard paper backup roll. Each diamond in the embossed pattern was about 7.9 mm high and about 3.2 mm wide. The embossed lines that formed the borders of adjoining diamonds were about 0.15 mm deep and about 1.6 mm wide.

Barrier Sheet D - A 2 inch by 10 inch (5.1 cm x 25.4 cm) sample of a spunbonded polyethylene plexifilamentary sheet more fully described in Example 1 as Type E (sold as TYVEK® Homewrap®) that had been embossed with a button pattern. The embossing was done a speed of 2.5 cm/sec using a 5.1 cm wide embossing roll having a diameter of 4 cm that was heated to 65° C, and was pressed against an 8 cm hard paper backup roll. The buttons were about 3.2 mm in diameter and 0.21 mm high. The buttons of the embossed pattern were spaced on 6.4 mm centers in the horizontal direction. The rows were offset by 3.2 mm.

Barrier Sheet E - An 8 inch by 10 inch sample (20.3 cm x 25.4 cm) of a spunbonded polyethylene plexifilamentary sheet more fully described in Example 1 as Type E (sold as TYVEK® Homewrap®) to which polyethylene, 10 pound, 18 mil (44.5 N, 0.46 mm) fishing line was applied in a vertical direction on one side thereof. The strings of fishing line were spaced every half inch.

Barrier Sheet F - An 8 inch by 10 inch (20.3 cm x 25.4 cm) sample of a spunbonded polyethylene plexifilamentary sheet more fully described in Example 1 as Type E (sold as TYVEK® Homewrap®) with a scrim material applied to the side of the sheet against which water was poured during the test. The scrim material was a polyethylene netting sold under the name VEXAR® H10 by DuPont of Canada of Whitby, Onatario, Canada. The scrim was made of polyethylene strands that were interconnected in a manner to form a diamond-shaped pattern in which the diamonds had a width of about 32 mm wide and a length of about 50 mm. The polyethylene strands were about 25 mils thick at the nodes where the strands connected to each other. The other portions of the strands were about 6 mils thick. The scrim material was applied to one side of the sheet material with the long axis of the diamonds oriented vertically. When this barrier sheet was put in the drainage tester, the scrim side of the barrier sheet was placed against the front panel 90 of the tester with the long lengthwise axis of the diamonds was oriented in the vertical direction.

Barrier Sheet G - An 8 inch by 10 inch sample (20.3 cm x 25.4 cm) of a spunbonded polyethylene plexifilamentary sheet more fully described in Example 1 as Type F flat sheet material that had been subjected to microstretching as described in U.S. Patent No. 4,223,059. In the microstretching process, the spunbonded sheet was passed between two geared rolls. The flat sheet was passed between passed two geared rolls that each had a length of 36 cm and a diameter of 20 cm. Each of the geared rolls was covered with 2.3 mm high teeth that extended the length of the roll and there were 16 teeth per inch (6.3 teeth per cm)

on the surface of the rolls. The two geared rolls were aligned such that the end of the tooth of one roll extended 1.4 mm into the groove of the other roll. The sheet was fed between the rolls at a speed of about 15 meters per minute (50 feet/min). The basis weight of the microstretched sheet was increased from about 61 g/m^2 to about 63 g/m^2 by the microstretching process. The sheet material maintains its thickness 47 (Figure 5) at about 127 microns (5 mils). The amplitude 48 of the waves in the waves (Figure 5) in the sheet were about 508 mm (20 mils) and the wave length 49 of the waves in the sheet were about 2.1 mm. The channels between wave peaks form substantially continuous and contiguous channels that run the full width (cross direction) of the sheet material on each side of the sheet material.

Barrier Sheet H - An 8 inch by 10 inch (20.3 cm x 25.4 cm) sample of the creped spunbonded polyethylene plexifilamentary sheet material of Example 7A.

Table 12

Barrier Sheet	Description	Drainage Rate (ml/hour/inch material)
A	Asphalt saturated Kraft Paper	0.6
B	TYVEK® - Flat	42
C	TYVEK® - Embossed diamond pattern	451
D	TYVEK® - Embossed button pattern	469
E	TYVEK® - Laminated with fishing line	4,235
F	TYVEK® - Laminated with scrim	33,103
G	TYVEK® - Microstreched	800
H	TYVEK® - Creped	8,107

(1 ml/hr/inch = .39 ml/hr/cm)

EXAMPLE 39

Four different creped barrier sheets were tested in a drainage testing unit in order to evaluate the relative drainage performance of the sheet materials. The drainage testing unit was like the unit described in Example 38 except that the trough opening 93 centered at the top edge of the front panel 90 was 5.3 inches (13.5 cm) wide.

The four barrier sheet materials listed below were tested one at a time in the drainage testing unit described in the paragraph above according to the

following procedure. For each test, a 8 inch by 10 inch (20.3 cm x 25.4 cm) barrier sheet material sample was clamped in the drainage testing unit as described above. Fifty milliliters of water was poured into the trough opening such that water was passed between the panel 90 and the barrier sheet material. The water drained out the bottom of the panels and was collected in the collection base. The time needed to pass a given amount of water through the assembly was measured. The timer was started as the water was first poured into the trough opining. The timer was stopped when the top surface of the water reached the bottom of the panels. If 15 minutes elapsed before all the water drained out, the amount of water collected was measured and a flow rate was calculated. The results are reported in Table 13 below in units of milliliters per hour per inch of width of the trough opening.

The following four barrier sheet materials were creped according to the creping process described in Examples 1-7A. The creping conditions for each of the sheet materials is listed in the table following the description of each sheet material.

Barrier Sheet A - An 8 inch by 10 inch (20.3 cm x 25.4 cm) sample of a Grade D asphalt saturated kraft paper with a basis weight of 9.0 oz/ yd^2 (305 g/m^2) and a 60 minute rating, manufactured by Leatherback Industries of Hollister, California. After creping, the sheet had 7 grooves per inch in a linear direction. The grooves had a length of 0.143 inch (0.363 cm) and an amplitude of 40 mils (1.02 mm).

Barrier Sheet B - An 8 inch by 10 inch sample (20.3 cm x 25.4 cm) of a microporous film laminated with a reinforcing scrim material, having an overall basis weight of 2.49 oz/yd^2 (84.4 g/m^2), and sold under the name R-Wrap® by Simplex, Inc. of Michigan. After creping, the sheet had 8 grooves per inch (per 2.54 cm) in a linear direction. The grooves had a length of 1/8 inch (0.32 cm) and an amplitude of 33 mils (0.84 mm).

Barrier Sheet C - A melt spun polypropylene fibrous sheet extrusion coated with a polypropylene film having a basis weight of 2.4 oz/yd^2 (81.4 g/m^2), sold under the name TYPAR® Housewrap™, and manufactured by Remay Inc. After creping, the sheet had 5 grooves per inch (per 2.54 cm) in a linear direction. The grooves had a length of 1/5 inch (0.51 cm) and an amplitude of 45 mils (1.14 mm).

Barrier Sheet D - The creped sheet material of Example 7A.

Creping Process Conditions	A	B	C	D
Roll Surface	Flat	Flat	Flat	Flat
Blade	Flat	Flat	Flat	Flat
Roll Temperature (°C)	22	66	121	68
Blade Setting	3	3	3	3

Table 13

Barrier Sheet	Description	Drainage Rate (ml/hour/inch material)
A	Asphalt Saturated Kraft Paper - Creped	6776.5
B	R-Wrap® - Creped	6776.5
C	TYPAR® -Creped	7819.0
D	TYVEK® - Creped	6776.5

(1 ml/hr/inch = .39 ml/hr/cm)

EXAMPLE 40

A test was conducted to compare the ability of following three barrier sheet materials to act as a break against capillary transfer of water through a wall system. A control wood sample without any barrier sheet was also tested.

Barrier Sheet A - A Grade D asphalt saturated kraft paper with a basis weight of 9.0 oz/ yd^2 (305 g/m^2) and a 60 minute rating, manufactured by Fortifiber Inc. of Los Angeles, California.

Barrier Sheet B - A flat spunbonded polyethylene plexifilamentary sheet material more fully described in Example 1 as Type E (sold as TYVEK® Homewrap®).

Barrier Sheet C - The creped spunbonded polyethylene plexifilamentary sheet material of Example 7A.

Four 7/8 inch (2.2 cm) thick pieces of white pine wood were cut in the shape of a 4 inch by 4 inch (10.2 cm x 10.2 cm) squares. The moisture level in the wood square was measured using a Lignomat K100 moisture meter made by Lignomat of Portland, Oregon. The moisture meter had two moisture sensing pins that were driven 12 mm into one side of each wood square. The moisture sensing pins were spaced 4 inches (10.2 cm) from each other on the diagonal of the wood square. The moisture meter was able to measure moisture content in the wood

until the moisture level reach about 25%. The side of the wood square with the moisture sensing pins was then covered with a 6 mil (0.15 mm) thick vapor impermeable polyethylene film. Each of the three barrier sheet materials was placed over the side of one of the wood squares opposite the side into which the moisture pins had been driven.

The wood squares used in the tests had initial moisture contents of from 8% to 10%. In the three tests in which the sample was covered with a barrier sheet material, the side of the wood square covered with the barrier sheet was set on top of a sponge that was larger than the wood square and was saturated with water for at least two weeks. The exposed surface of the fourth wood square was also placed on a water saturated sponge. The moisture level in each wood sample was measured on a regular basis over the next two weeks. The average rate of moisture gain during the first week that the wood square was on the saturated sponged and the maximum moisture level reached during the two week period is reported in Table 14 below.

Table 14

	Barrier Sheet Type	Initial Moisture Content in Wood (%)	Wood Moisture Content after 7 Days (%)	Max Rate of Moisture Gain over any 4 day period (%/hr)	Max Moisture Content During First 14 Days (%)
A	Asphalt Saturated Paper	8.1	15.2	0.052	17.8
B	Flat Spunbonded - Type E	8.4	13.1	0.052	14.7
C	Creped Spunbonded - from Ex. 7A	9.9	12.8	0.017	13.5
	No Barrier Sheet Material	9.9	27.9	.201	30

EXAMPLE 41

A flat spunbonded barrier sheet (Sheet Type E from Ex. 1) and a creped spunbonded barrier sheet (Sheet from Ex. 7A) were tested for mechanical durability according to ASTM E330. This test measures the structural integrity of a wall section under a wind load. The wall section in this Example was a barrier sheet material applied to a wood frame as found when a building is under construction before the barrier sheet material has been covered with an exterior protective layer such as siding, stucco, or brick.

For each test, the sheet material was attached to an 2.67 foot (81.4 cm) by 2.5 foot (76.2 cm) wall frame section built from vertical 2x4 inch

wood studs arranged on 16 inch (40.6 cm) centers. The sheet material was stapled to one side of the studs with 1 inch staples. The staples were applied in one of two patterns. In Pattern 1, the staples were applied every 5 inches (12.7 cm) along the studs. In Pattern 2, the staples were applied every fifteen inches (38.1 cm) along the studs. Each wall section was exposed to fan generated pressure against the backside (the stud side) of the wall section in order to simulate wind induced pressure. The pressure started at 0 and was then increased by an increment of 5 pounds per square foot (0.24 kPa) every 10 seconds. The pressure at which the sheet ripped off one or more of the staples is reported in Table 15 below. The wind speed that would generated the failure pressure is also reported in Table 15 below.

Table 15

Barrier Sheet	Flat Spunbonded (Type E from Ex. 1)	Creped Spunbonded (Sheet from Ex. 7A)
Tensile Strength - MD (N/cm)	40	49
Tensile Strength - CD (N/cm)	49	50
Staple Pattern 1		
Failure Pressure (lbs/foot^2)	10	71.9
Equivalent Wind Speed (mph)	62.5	167.5
Staple Pattern 2		
Failure Pressure (lbs/foot^2)	6.3	28.7
Equivalent Wind Speed (mph)	50	106

(1 lb/ft^2 = 0.048 kPa; 1mph =1.6 km/hr)

EXAMPLE 42

Three different barrier sheets were tested in a drainage testing unit in order to evaluate the tendency of the barrier sheet materials to reduce the transmission of water through a nail hole. The drainage testing unit was similar to the testing unit shown in Figure 10. The testing unit included two plexiglas panels that were 24 inches (61.0 cm) tall, 18 inches (45.7 cm) wide, and 0.35 inches (0.89 cm) thick. The front panel had a trough opening that was 12 inches (30.5 cm) wide centered at the top edge of the front panel. Sheets of barrier materials were inserted between the panels in a manner such that the top edge of the sample aligned with the top edge of back panel and the vertical midline of the sample was centered in the trough opening. Six clamps held the panels together with a force of about 30 pounds (133 N). The two top clamps were positioned at

the top edge of either edge of the panels, the third and fourth clamps were positioned 13 inches (33 cm) from the top of the panels, and the fifth and sixth clamps were positioned 23 inches (58 cm) from the top of the panels. The clamped plexiglas panels fit in a collection base that held the plexiglas panels about 2.5 inches (6.4 cm) above the bottom of the collection base so as to permit liquid between the panels to drain out of the panels.

A 1/8 inch (0.32 cm) hole was drilled in the center of both panels 10 inches (25.4 cm) from the top of the panels. Each of the samples was placed between the panels of the tester with a sheet of tissue paper between each sample and the back panel of the tester. A 1/8 inch (0.32 cm) screw was inserted through the hole in the front panel, the sample, the tissue paper, and the hole in the back panel. The screw was tightened the same amount on each sample.

A volume of 2000 ml of water was poured into the tester against the front of the sheet. The amount of water passing through the sheet at the screw hole was determined by measuring the weight of the tissue paper before and after the water passed through the tester.

The three barrier sheet materials listed below were tested one at a time in the drainage testing unit described in the paragraph above according to the procedure described above. The results are reported in Table 16 below.

Barrier Sheet A - An 18 inch by 24 inch (47.7 cm x 61.0 cm) sample of a Grade D asphalt saturated kraft paper with a basis weight of 9.0 oz/ yd^2 (305 g/m^2) and a 60 minute rating, manufactured by Leatherback Industries of Hollister, California.

Barrier Sheet B - An 18 inch by 24 inch (47.7 cm x 61.0 cm) sample of a flat spunbonded polyethylene plexifilamentary sheet material more fully described in Example 1 as Type E (sold as TYVEK® Homewrap®).

Barrier Sheet C - An 18 inch by 24 inch (47.7 cm x 61.0 cm) sample of the creped spunbonded polyethylene plexifilamentary sheet material of Example 7A.

Table 16

Barrier Sheet	Description	Water penetration through hole in barrier material (ml)	Relative penetration to Sample A
A	Asphalt saturated Kraft Paper	3.9812	X
B	TYVEK® - Flat	4.0429	0.98X
C	TYVEK® - Creped	0.0283	0.0071X

It will be apparent to those skilled in the art that modifications and variations can be made in breathable composite sheet material of this invention. The invention in its broader aspects is, therefore, not limited to the specific details or the illustrative examples described above. Thus, it is intended that all matter contained in the foregoing description, drawings and examples shall be interpreted as illustrative and not in a limiting sense.

WHAT IS CLAIMED IS:

1. A construction membrane comprising a barrier sheet material having a basis weight of less than 600 g/m^2, a hydrostatic head of greater than 12 cm, a Gurley Hill porosity of greater than 10 seconds, a moisture vapor transmission rate, measured by the LYSSY method, of at least 25 $g/m^2/day$, and integral channel means oriented in at least one general direction for providing a path by which a liquid against the sheet can drain.

2. The construction membrane of claim 1 wherein said barrier sheet material is a unitary sheet.

3. The construction membrane of claim 1 wherein said integral channel means comprises grooves formed on at least one side of the barrier sheet material.

4. The construction membrane of claim 2 wherein said barrier sheet material has a basis weight of less than 300 g/m^2, a hydrostatic head of greater than 50 cm, a Gurley Hill porosity of greater than 60 seconds, and a moisture vapor transmission rate, measured by the LYSSY method, of at least 100 $g/m^2/day$.

5. The construction membrane of claim 4 wherein said barrier sheet material has a basis weight of less than 125 g/m^2, a hydrostatic head of greater than 150 cm, a Gurley Hill porosity of greater than 120 seconds, and a moisture vapor transmission rate, measured by the LYSSY method, of at least 250 $g/m^2/day$.

6. The construction membrane of claim 1 wherein said barrier sheet material has a basis weight of less than 125 g/m^2, a hydrostatic head of greater than 150 cm, a Gurley Hill porosity of greater than 120 seconds, and a moisture vapor transmission rate, measured by the LYSSY method, of at least 250 $g/m^2/day$.

7. The construction membrane of claim 1 wherein said barrier sheet material is a fibrous sheet.

8. The construction membrane of claim 7 wherein said fibrous sheet is a nonwoven sheet of synthetic fibers.

9. The construction membrane of claim 8 wherein said nonwoven sheet is a spunbonded sheet comprised of polyolefin polymer fibers.

10. The construction membrane of claim 9 wherein said spunbonded sheet consists essentially of polyethylene plexifilamentary film fibrils.

11. The construction membrane of claim 2 wherein said integral channel means if formed in said barrier sheet material by a process selected from the group of creping, embossing and microstretching.

12. The construction membrane of claim 2 wherein said integral channel means comprises grooves formed on at least one side of the barrier sheet material.

13. The construction membrane of claim 12 wherein said barrier sheet material is a creped sheet and said sheet is creped with a pattern of longitudinally extending substantially contiguous waves, said waves having an amplitude of at least 200 microns and a wave length of at least 1 mm.

14. The construction membrane of claim 12 wherein said barrier sheet material is a microstretched sheet and said microstretched sheet has a pattern of longitudinally extending substantially contiguous waves, said waves having an amplitude of at least 200 microns and a wave length of at least 1 mm.

15. The construction membrane of claim 12 wherein said barrier sheet material has a first surface and said barrier sheet is an embossed sheet , the sheet being embossed with a pattern of raised portions that are spaced from each other and extend at least 100 microns out from the first surface of said barrier sheet material.

16. The construction membrane of claim 1 wherein said integral channel means comprises spacing means attached to at least one side of the barrier sheet material, said spacing means having a thickness of at least 200 microns and is selected from the group of synthetic scrim materials, plastic line, coarse nonwovens, and adhesive lumps.

17. The construction membrane of claim 3 wherein said barrier sheet has a drainage rate, measured according to the Barrier Sheet Drainage Test Method, of at least 150 ml/hr/inch.

18. The construction membrane of claim 17 wherein said barrier sheet has a drainage rate, measured according to the Barrier Sheet Drainage Test Method, of at least 1000 ml/hr/inch.

19. The construction membrane of claim 18 wherein said barrier sheet has a drainage rate, measured according to the Barrier Sheet Drainage Test Method, of at least 2000 ml/hr/inch.

20. A wall structure comprising a support frame, a barrier sheet material over said support frame, and an exterior protective layer over said barrier sheet, wherein said barrier sheet material has a basis weight of less than 600 g/m^2, a hydrostatic head of greater than 12 cm, a Gurley Hill porosity of greater than 10 seconds, a moisture vapor transmission rate, measured by the LYSSY method, of at least 25 $g/m^2/day$, and integral channel means oriented in a generally vertical direction for providing a path by which a liquid against the sheet can drain.

21. The wall structure of claim 20 wherein said exterior protective layer is selected from the group of stucco, hybrid stucco, brick, stone, wood siding, metal siding, and synthetic siding materials.

22. The wall structure of claim 21 wherein said barrier sheet material is a unitary sheet.

23. The wall structure of claim 21 wherein said barrier sheet material has a basis weight of less than 300 g/m^2, a hydrostatic head of greater than 50 cm, a Gurley Hill porosity of greater than 60 seconds, and a moisture vapor transmission rate, measured by the LYSSY method, of at least 100 $g/m^2/day$.

24. The wall structure of claim 23 wherein said barrier sheet material is a fibrous sheet.

25. The wall structure of claim 24 wherein said barrier sheet material is a spunbonded sheet comprised of polyolefin polymer fibers.

26. The construction membrane of claim 25 wherein said integral channel means if formed in said barrier sheet material by a process selected from the group of creping, embossing and microstretching.

27. The construction membrane of claim 26 wherein said integral channel means comprises grooves formed on at least one side of the barrier sheet material.

28. A method for removing moisture from an exterior wall of a structure, comprising the steps of:

constructing a support frame;

covering said support frame with a barrier sheet material, said barrier sheet material having a basis weight of less than 600 g/m^2, a hydrostatic head of greater than 12 cm, a Gurley Hill porosity of greater than 10 seconds, a moisture vapor transmission rate, measured by the LYSSY method, of at least 25 $g/m^2/day$, and integral channel means oriented in a generally vertical direction for providing a path by which a liquid against the sheet can drain; and

covering the barrier sheet material with an exterior protective layer.

AMENDED CLAIMS

[received by the International Bureau on 26 May 1999 (26.05.99); original claims 7, 8, and 24 cancelled ; new claim 29 added ; remaining claims unchanged (4 pages)]

1. A construction membrane comprising a nonwoven, spunbonded, barrier sheet material consisting essentially of synthetic fibers, said sheet material having a basis weight of less than 600 g/m^2, a hydrostatic head of greater than 12 cm, a Gurley Hill porosity of greater than 10 seconds, a moisture vapor transmission rate, measured by the LYSSY method, of at least 25 g/m^2/day, and integral channel means oriented in at least one general direction for providing a path by which a liquid against the sheet can drain.

2. The construction membrane of claim 1 wherein said barrier sheet material is a unitary sheet.

3. The construction membrane of claim 1 wherein said integral channel means comprises grooves formed on at least one side of the barrier sheet material.

4. The construction membrane of claim 2 wherein said barrier sheet material has a basis weight of less than 300 g/m^2, a hydrostatic head of greater than 50 cm, a Gurley Hill porosity of greater than 60 seconds, and a moisture vapor transmission rate, measured by the LYSSY method, of at least 100 g/m^2/day.

5. The construction membrane of claim 4 wherein said barrier sheet material has a basis weight of less than 125 g/m^2, a hydrostatic head of greater than 150 cm, a Gurley Hill porosity of greater than 120 seconds, and a moisture vapor transmission rate, measured by the LYSSY method, of at least 250 g/m^2/day.

6. The construction membrane of claim 1 wherein said barrier sheet material has a basis weight of less than 125 g/m^2, a hydrostatic head of greater than 150 cm, a Gurley Hill porosity of greater than 120 seconds, and a moisture vapor transmission rate, measured by the LYSSY method, of at least 250 g/m^2/day.

9. The construction membrane of claim 2 wherein said synthetic fibers consist essentially of polyolefin polymer fibers.

10. The construction membrane of claim 9 wherein said polyolefin polymer fibers consist essentially of polyethylene plexifilamentary film fibrils.

11. The construction membrane of claim 2 wherein said integral channel means if formed in said barrier sheet material by a process selected from the group of creping, embossing and microstretching.

12. The construction membrane of claim 2 wherein said integral channel means comprises grooves formed on at least one side of the barrier sheet material.

13. The construction membrane of claim 12 wherein said barrier sheet material is a creped sheet and said sheet is creped with a pattern of longitudinally extending substantially contiguous waves, said waves having an amplitude of at least 200 microns and a wave length of at least 1 mm.

14. The construction membrane of claim 12 wherein said barrier sheet material is a microstretched sheet and said microstretched sheet has a pattern of longitudinally extending substantially contiguous waves, said waves having an amplitude of at least 200 microns and a wave length of at least 1 mm.

15. The construction membrane of claim 12 wherein said barrier sheet material has a first surface and said barrier sheet is an embossed sheet , the sheet being embossed with a pattern of raised portions that are spaced from each other and extend at least 100 microns out from the first surface of said barrier sheet material.

16. The construction membrane of claim 1 wherein said integral channel means comprises spacing means attached to at least one side of the barrier sheet material, said spacing means having a thickness of at least 200 microns and is selected from the group of synthetic scrim materials, plastic line, coarse nonwovens, and adhesive lumps.

17. The construction membrane of claim 3 wherein said barrier sheet has a drainage rate, measured according to the Barrier Sheet Drainage Test Method, of at least 150 ml/hr/inch.

18. The construction membrane of claim 17 wherein said barrier sheet has a drainage rate, measured according to the Barrier Sheet Drainage Test Method, of at least 1000 ml/hr/inch.

19. The construction membrane of claim 18 wherein said barrier sheet has a drainage rate, measured according to the Barrier Sheet Drainage Test Method, of at least 2000 ml/hr/inch.

20. A wall structure comprising a support frame, a barrier sheet material over said support frame, and an exterior protective layer over said barrier sheet, wherein said barrier sheet material is a nonwoven, spunbonded sheet consisting essentially of synthetic fibers, said sheet material having a basis weight of less than 600 g/m^2, a hydrostatic head of greater than 12 cm, a Gurley Hill porosity of greater than 10 seconds, a moisture vapor transmission rate, measured by the LYSSY method, of at least 25 g/m^2/day, and integral channel means oriented in a generally vertical direction for providing a path by which a liquid against the sheet can drain.

21. The wall structure of claim 20 wherein said exterior protective layer is selected from the group of stucco, hybrid stucco, brick, stone, wood siding, metal siding, and synthetic siding materials.

22. The wall structure of claim 21 wherein said barrier sheet material is a unitary sheet.

23. The wall structure of claim 21 wherein said barrier sheet material has a basis weight of less than 300 g/m^2, a hydrostatic head of greater than 50 cm, a Gurley Hill porosity of greater than 60 seconds, and a moisture vapor transmission rate, measured by the LYSSY method, of at least 100 g/m^2/day.

25. The wall structure of claim 22 wherein said synthetic fibers consist essentially of polyolefin polymer fibers.

26. The wall structure of claim 25 wherein said integral channel means if formed in said barrier sheet material by a process selected from the group of creping, embossing and microstretching.

27. The wall structure of claim 26 wherein said integral channel means comprises grooves formed on at least one side of the barrier sheet material.

28. A method for removing moisture from an exterior wall of a structure, comprising the steps of:

constructing a support frame;

covering said support frame with a barrier sheet material, said barrier sheet material being a nonwoven, spunbondedd sheet consisting essentially of synthetic fibers, said barrier sheet material having a basis weight of less than 600 g/m^2, a hydrostatic head of greater than 12 cm, a Gurley Hill porosity of greater than 10 seconds, a moisture vapor transmission rate, measured by the LYSSY method, of at least 25 g/m^2/day, and integral channel means oriented in a generally vertical direction for providing a path by which a liquid against the sheet can drain; and

covering the barrier sheet material with an exterior protective layer.

29. The wall structure of claim 25 wherein the polyolefin polymer fibers consist essentially of polyethylene plexifilamentary film fibrils.

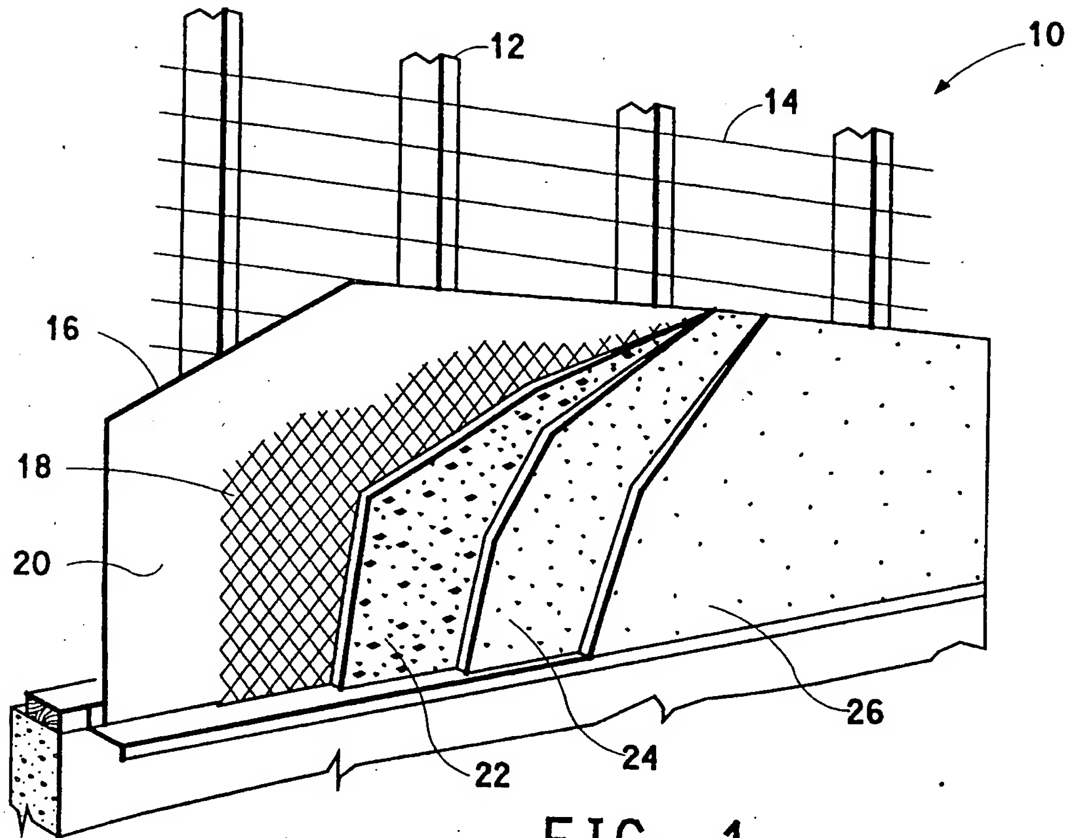

FIG. 1
(PRIOR ART)

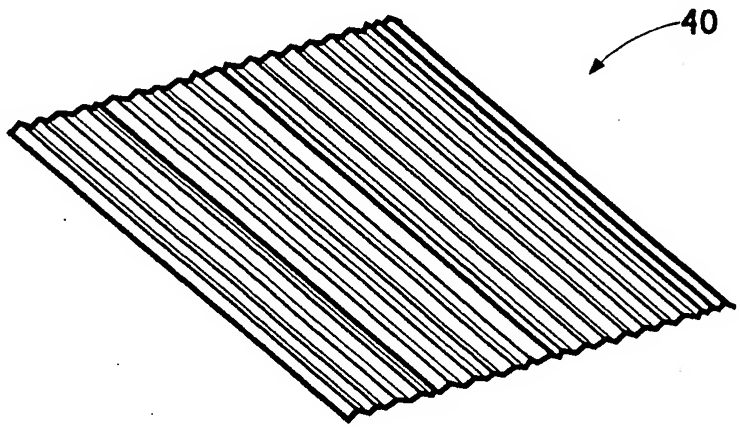

FIG. 2

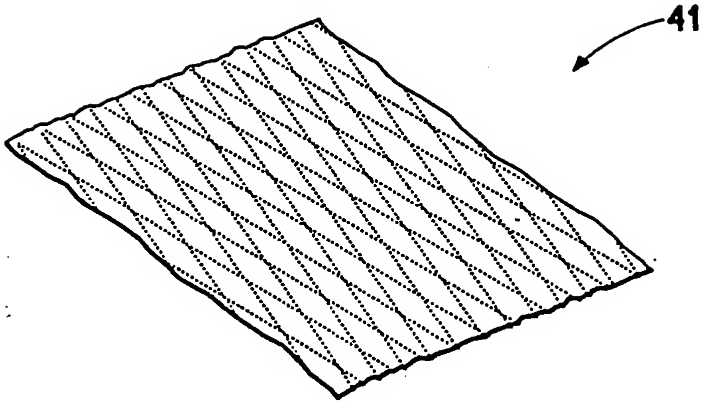

FIG. 3

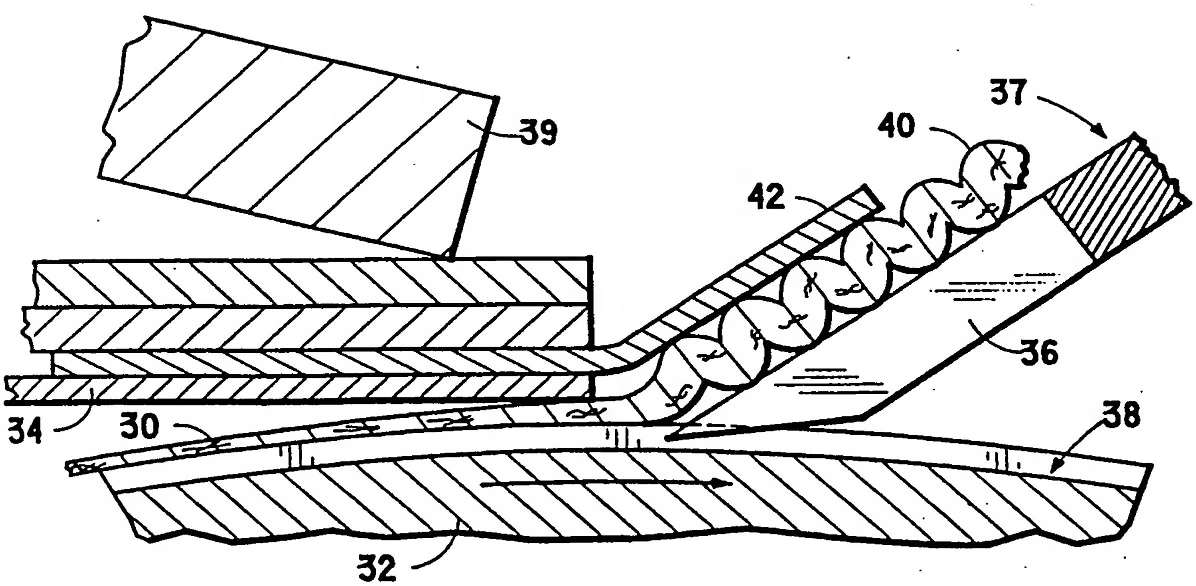

FIG. 4

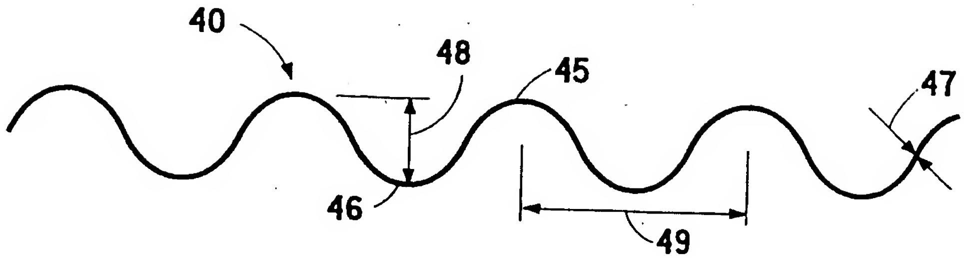

FIG. 5

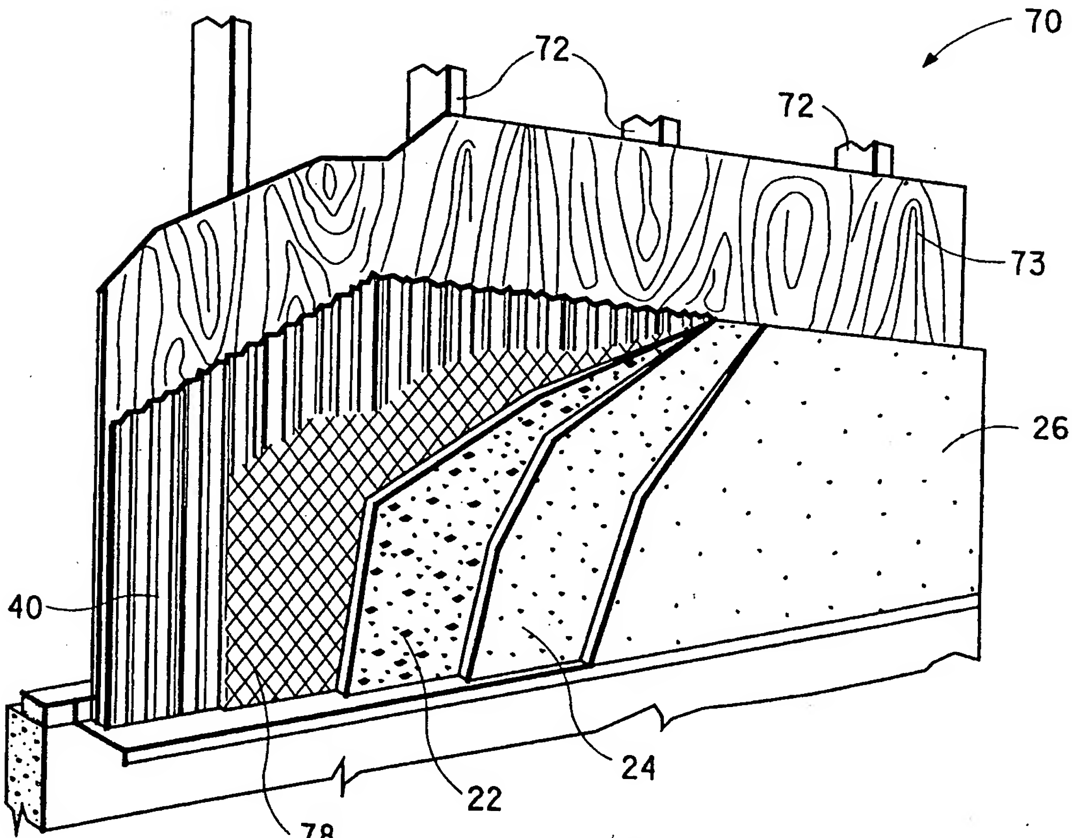

FIG. 6

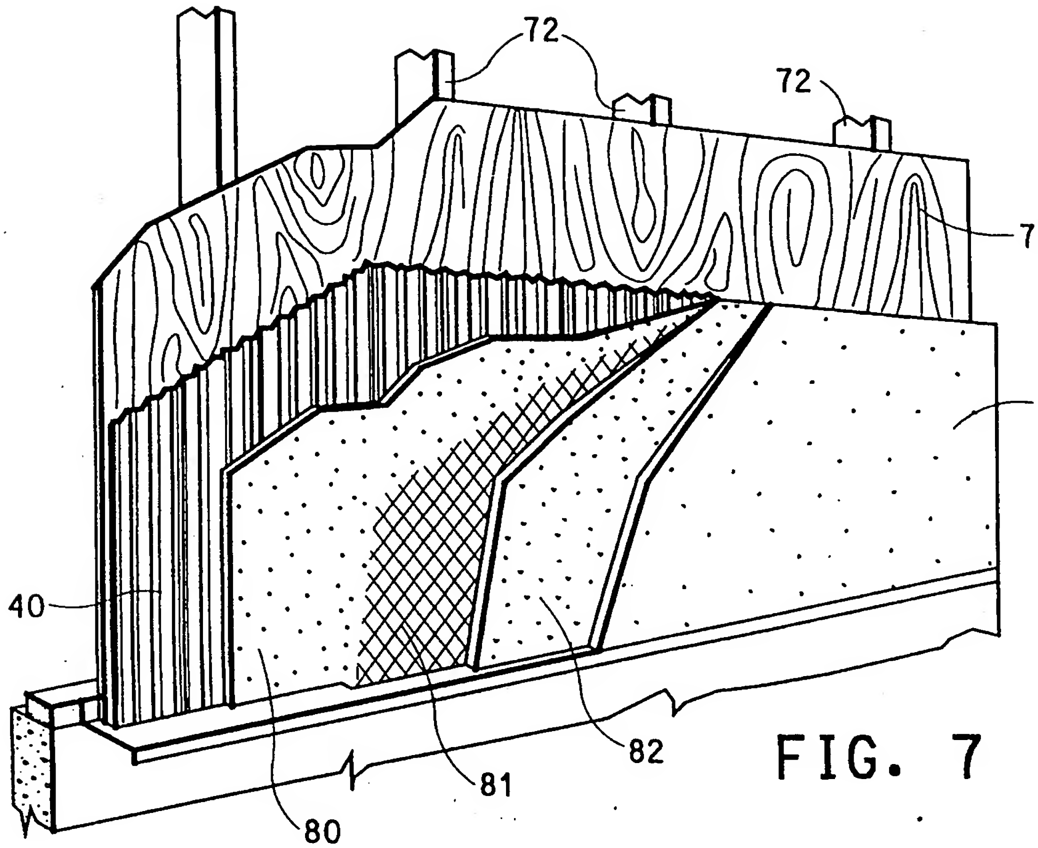

FIG. 7

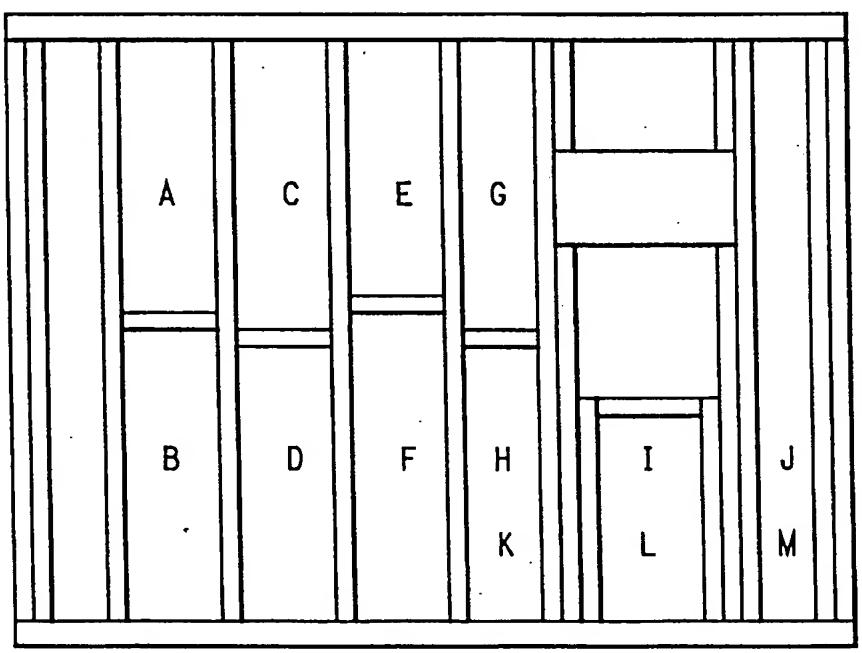

FIG. 8

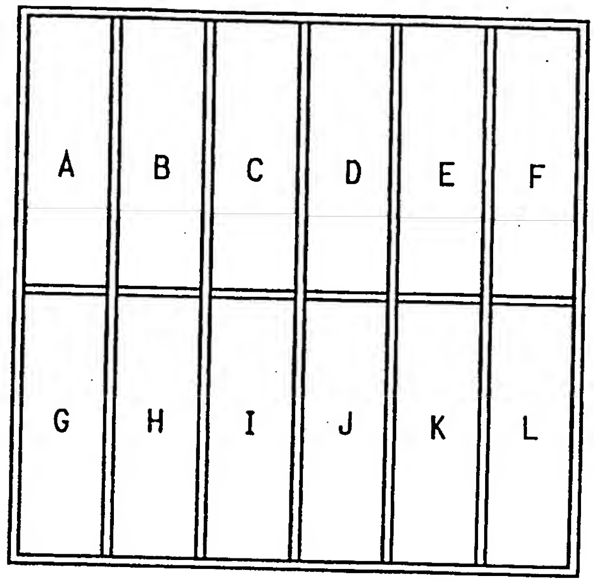

FIG. 9

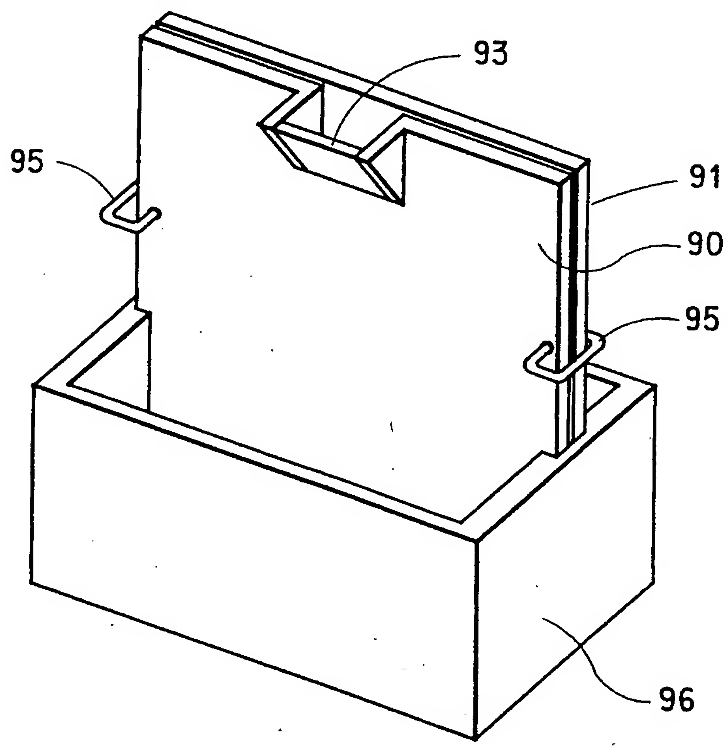

FIG. 10

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 98/25970

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 E04B1/62

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 E04B D04H

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 929 303 A (SHETH PARESH J) 29 May 1990 see the whole document	1-12,20, 23-28
A	WO 97 40224 A (DU PONT) 30 October 1997 cited in the application see the whole document	1,2,4-11
A	PATENT ABSTRACTS OF JAPAN vol. 097, no. 005, 30 May 1997 & JP 09 001712 A (C I KASEI CO LTD), 7 January 1997 see abstract	1,3, 7-10,16, 20,328

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
19 March 1999	31/03/1999

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Vrugt, S

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INTERNATIONAL SEARCH REPORT

In ational Application No
PCT/US 98/25970

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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A	US 4 696 138 A (BULLOCK CHRISTOPHER A) 29 September 1987 see column 1, line 15 - line 56 see column 6, line 15 - line 45 see figure 3 ---	1,2, 20-22,28
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